The Welding Engineer

Edited by L. B. Mackenzie

$3.00 per year in U.-S. | Reg. U. S. Pat. Office | $4.00 per year abroad

Vol. 7 | Chicago, Ill. 608 S. Dearborn St. | JULY, 1922 | New York 14 Vanderwater St. | No. 7

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Buyers' Index

Readers of The Welding Engineer will find this index to contain the most accurate information obtainable relating to welding apparatus and supplies. The advertising section includes the principal manufacturers of the United States.

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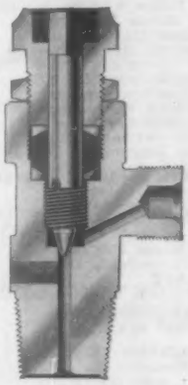

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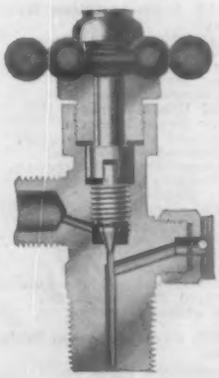

The Burdett Standard High Pressure Valve

This is a high grade single seat valve ***at a popular price.*** The swivel mounted tapered seat tip is made of monel metal. It does not twist nor wear so there are ***no new seats to buy*** and no "gas leakage" complaints from customers.

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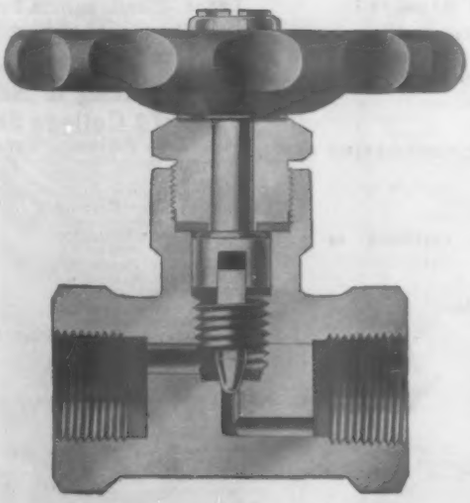

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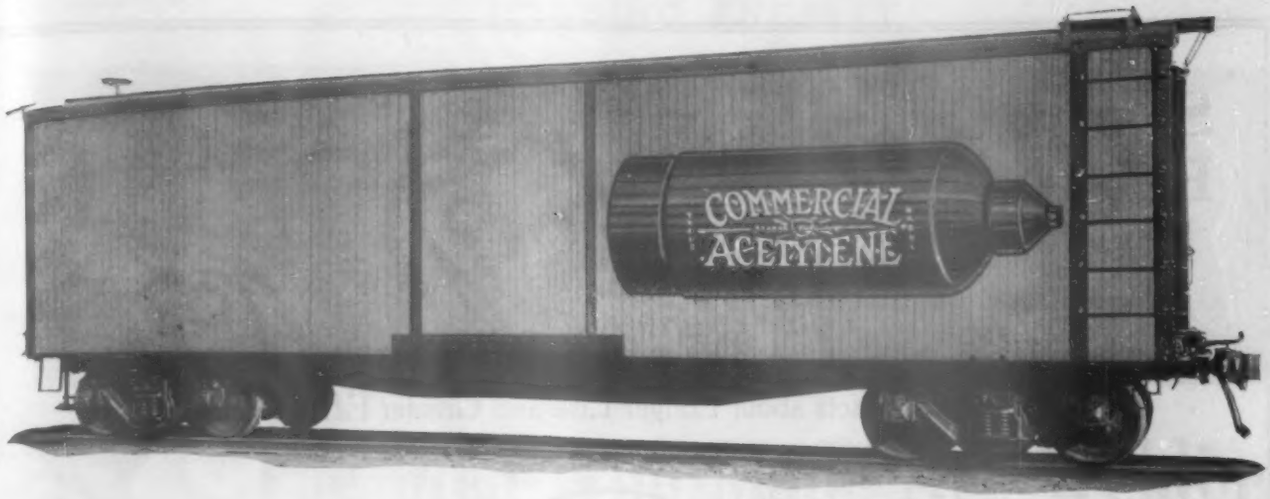

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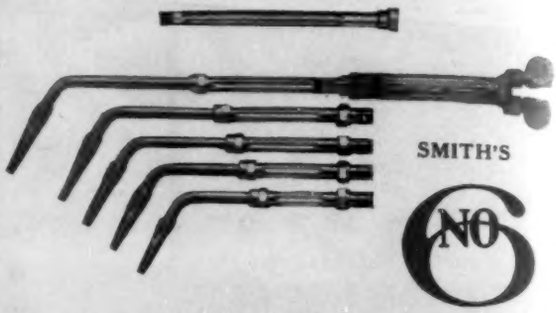

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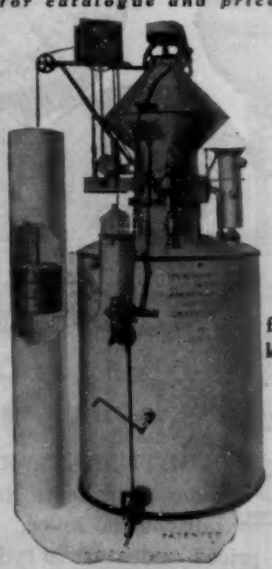

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GAS WELDED PRESSURE VESSELS*

Composition of Best Base Metal and Filler Rod for Good Welds—Design of Weld—Annealing and Forging

By S. W. Miller†

THE use of containers or vessels made of various materials for holding gases and liquids under pressure has been a common practice for many years.

These vessels have been made of all kinds of material and with or without joints as conditions and the fancy of the designer controlled. The vessels carrying heavy pressure have been usually, in the past, of riveted construction, although forge welding of such vessels, or parts thereof, has been practiced for a long time.

Forge welding is expensive and therefore not suitable for many types of vessels. Riveted joints have also been used because of their ease of construction and of the certainty with which their efficiency may be calculated. Much of this certainty is due to our long acquaintance with them; to the many tests that have been made on them, and to the fact that they may be readily inspected both during and after their manufacture. From a construction standpoint, however, riveted joints are objectionable for many reasons, among which is their decided tendency to leak.

It must be always kept in mind also that many failures have occurred with riveted construction and that such construction is not as simple a matter as it would appear, if one were to be guided entirely by what is sometimes said. The fact of the matter is that in the case of a great many people, familiarity with riveted construction has developed a sort of contempt for the dangers accompanying it. It is only necessary to recall the protests that were made against the restrictions on double-riveted lap joints in the Boiler Code to see that this is true.

Of recent years fusion welding of such vessels, usually in steel plate or sheet, has been used to a very great extent, the welding generally being done by the oxy-acetylene or metallic-electrode arc processes. These processes, when properly applied under proper conditions, produce a safe structure that has great advantages in regard to cost, lightness, strength and freedom from possible leakage.

Single Objection to Fusion Welding

The only objection that can be raised against vessels made by fusion welding processes is that the integrity of the weld depends very largely on the honesty and ability of the welder, because it is very difficult, if not impossible, to inspect the weld satisfactorily. This fact, coupled with accidents that have occurred, have created in the minds of many a suspicion that fusion welding processes are not safe and that pressure vessels made by their use should be condemned.

Unfortunately, it is true that there have been accidents of a more or less serious nature from defective welds, or from those improperly made. It is equally true and equally unfortunate that vessels, whose parts have been joined by other means than fusion welding, have been equally productive of accidents, if not more so, and while it is also true that failures of seamless vessels have occurred, yet the advocates of fusion welding cannot rely on any such statements to help their case.

Construction of Unfired Pressure Vessels

The real difficulty in the case of fusion-welded pressure vessels is that the art is so new that it has not been reduced to standard practice. The first welding torch was patented in 1903 and the progress of the art was very slow at first. Really the welding of pressure vessels has not been in use to any great extent for more than 10 or 12 years, and it is hardly to be wondered at that the knowledge of the art is limited compared with the knowledge of riveted joints and of the best methods of making them. Undoubtedly, when fusion welding will have been in use for as many years as riveting, those living at that time will wonder why there was any question of the value and safety of fusion welding processes.

But on those of us who are living now and who are interested in fusion welding processes, lies the burden of devising means and ways of producing safe vessels, to which we can point with satisfaction and pride as being not only the equal of other constructions, but far superior to them.

The two main points of superiority in such vessels are their freedom from leakage and their much greater efficiency of the joint. As in other developments of mechanical and industrial processes, much has been done in the way of fusion welding by cut-and-try methods, and those of us who have been in the business for years can testify to the difficulties encountered. These troubles only stimulated the enthusiastic worker, and methods were developed which overcame many of them, but at great expense and loss of time.

Welding Efficiency

When welding began to be studied in a more careful manner, much was said about the efficiency of a weld, i. e., the ratio of the strength of a weld to the strength of the material of which it was made.

In what follows, I feel that it will be well to limit discussion to vessels made of steel plate or sheet, because it is this material, and vessels made of it, with which we are principally concerned. I believe, however, that the principles which I shall attempt to develop are equally applicable to other materials.

It was found by trial that the efficiency varied greatly, ranging from as low as 20 per cent to as high as 95 per cent, and sometimes higher. There was much discussion as to what percentage should be used for the design of welded pressure vessels, and it was not to be wondered at that with the wide variation in efficiency, no agreement could be arrived at as to what value should be assigned to the weld.

After considerable study and experiment, I arrived at the conclusion that it would be necessary to eliminate the consideration of this variable and unknowable efficiency, by either making the weld so strong that rupture could not occur there, or by making the plate so weak that rupture would occur there always. It may seem that these two statements are the same, but they are not, as will be explained later, and it has finally become very clear to me that the second statement is the basic principle for the construction of safe welded pressure vessels.

Factors Affecting Weld Efficiency

It is easy to see that the efficiency of a weld may vary for different reasons: the welder may be inefficient, the welding material may be poor, the torch or electrode may not be capable of proper operation, but beyond all these things, is the fact that the materials, or base metals, which have been used for making tests vary very widely in strength. One test may have been made with 50,000-lb. material, another, with material of 65,000 lb. tensile strength. With the same welding material and the same operator, the weld metal in the two cases should have the same strength. If we assume this at 50,000 lb. tensile strength, the weld in the low-tensile-strength plate will have efficiency of 100 per cent, while in the high-strength plate the efficiency would be about 77 per cent. Evidently these two results cannot be compared unless the strength of the base material be considered. Therefore, one of

Extract from a paper presented before the Spring Meeting, Atlanta, Ga., May 8 to 11, 1922, of The American Society of Mechanical Engineers.

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the first things to do is to decide what kind of material to use for the base metal.

It has been known for years that forge welding gives best results in low-carbon material, and on the other hand, that tool steel is difficult, if not impossible, to forge-weld if full strength is desired. This is natural, because the high-carbon steel is easily burned at a temperature that will injure the low-carbon material but little.

In the course of my investigations, I found several years ago, that in two very large shops, where fusion welding was one of the most important processes, they were using material of this character and had had splendid success with it. I have made numerous tests on various kinds of steel plate and found in these tests that the best welds were made in material of the same general character, that is, low tensile strength plate.

Composition of Best Base Weld Metal

I have, therefore, come to the conclusion that the base metal most successful for welding is of about the following chemical composition:

Carbon, per cent	0.15 max.
Manganese, per cent	0.60 max.
Sulphur, per cent	0.05 max.
Phosphorus, per cent	0.04 max.

It should have about the following physical characteristics:

Tensile strength	50,000 lb. max.
Yield point	at least half tensile strength
Elongation, per cent in 8 inch,	$\frac{1{,}500{,}000}{\text{tensile strength}}$

Further investigation showed, much to my surprise, that material of this composition and strength would not always weld well and I believe I have demonstrated that there is something more necessary than the above specifications if the most satisfactory material is to be obtained.

The microscope shows that steel which welds badly contains large numbers of small non-metallic impurities, which are probably oxides or silicates, because the percentage of sulphur is too small to form so much manganese sulphide. This indicates poorly made steel, and evidently the co-operation of the steel maker is needed if we are to have satisfactory material with which to work.

I have occasionally found that improperly annealed steel also gives trouble in welding even in the absence of non-metallic impurities, but not to such an extent.

I have no hesitation in saying that steel of the above chemical composition, if free from non-metallic impurities, is the best metal, in my opinion, for the making of pressure vessels.

There is another reason for this statement and it lies in the fact that such material is very ductile, and will stand punishment in the nature of overheating or mechanical work that higher carbon steel will not stand, and inasmuch as there are always strains in welding due to the contraction of the heated metal, any material that will stand these strains and absorb them is much superior to one that will not.

Much trouble has been experienced in welding long seams in such high-carbon material as ship plate and much credit is due to those who have exercised ingenuity enough to overcome this trouble, but it is much easier, cheaper, and safer to avoid it than to overcome it, and all my experience shows that the use of the material suggested will avoid the trouble.

Welding-Wire Composition

The welding wire ordinarily used for gas welding is a low carbon material of about the following composition:

Carbon, per cent	0.06 max.
Manganese, per cent	0.15 max.
Phosphorus, per cent	0.03 max.
Sulphur, per cent	0.03 max.

It is a very carefully made product and of superior quality, and gives very good results. In half-inch plate of sufficient strength to break the weld it gives a tensile strength of about 52,000 lb. per square inch in a double "V" weld when the weld is of equal section with the plate. I do not believe that it is strong enough, however, to allow for welds that are somewhat imperfect, if it is desired to always break the plate and never the weld.

I have therefore advocated low-carbon nickel-steel wire of the following composition:

Carbon, per cent	0.15 to 0.25
Manganese, per cent	0.50 to 0.80
Sulphur, per cent	0.045
Phosphorus, per cent	0.04
Nickel, per cent	3.25 to 3.75

This corresponds to the Society of Automotive Engineers' specification No. 2320. This material tested under the same conditions as the ordinary welding wire above mentioned, gives a tensile strength of from 57,000 lb. to 63,000 lb. in the weld.

Another Good Welding Wire

I have no doubt that other equally good or better welding materials can be devised. I know of one that is better in some respects, but it is not quite ready for the market. Tests made with it have shown an average in 12 tests of 62,400 lb. with a maximum of 64,500, and a minimum of 58,600, so that the results are quite uniform.

It should be clearly understood that I am not presenting the claims of any particular materials, but that I am only giving the results of my personal experience. I am advocating very strongly the use of a welding material of such character as will most easily make a sound, clean weld, of a base metal that is weak enough to absorb the welding strains and to break always outside of the weld, and of methods that will always insure these results.

Under the head of methods, the type of weld is of importance. I have demonstrated to my own satisfaction that a single "V" weld is never as strong as a double "V" weld. The latter requires twice as much welding material and is therefore more expensive. A single "V" weld cannot usually be bent backward, i. e., with the top of the "V" concave to the bend. Under such a test, the chances are very great that the break will take place through the center of the weld. The reason for this is, that it is impossible to get freedom from defects at the bottom of the "V." This is shown clearly by the photographs.

Weakness of Single "V" Weld

Iron oxide melts at a lower temperature than the steel, and it flows down the side of the "V," accumulating underneath the edges due to its surface tension, and when the welding rod is applied there is a film of oxide at the bottom of the "V" or under it, over which the melted metal flows, leaving a line of weakness. It also works up more or less into the bottom of the "V," leaving cracks which are frequently microscopic but none the less dangerous.

According to my observation, the ruptures of welds, not only in pressure vessels, or steel plate or sheet, but in cast iron and other metals, have been with single "V" welds. I do not recall a case of a double "V" welded piece giving way in the weld. We never use a single "V" weld if it is possible to use a double "V," even if it is necessary to weld overhead to make the bottom of the "V" sound.

Of course, where there can be no bending, as in the case of a convex head welded to a shell, there is no particular danger, especially as the fiber stress is low. Also, if the double "V" weld cannot be used for any reason, there can be no argument, but the stress must be kept at such a point as will be safe, or the design changed to permit the use of the double "V."

A double "V," on the other hand, permits of the burning out of these defects, and if any do remain, they are in the center of the weld, where their only effect is to slightly reduce the tensile strength, which can be compensated for by increasing the thickness of the weld. This cannot be done with the single "V," because increasing the thickness of the weld on one side increases the fiber stress due to a given pressure, on account of the eccentricity of the load. This can be readily seen in the testing machine, because the test piece bends toward the bottom of the "V."

Proper Welding Conditions Essential

The use of a double "V" may not be necessary in all cases, but for all important work I am satisfied that it should be used. With double "V" welding, it is necessary to clean the scale carefully from the second side welded before welding. This scale comes from the action of the air on the red-hot metal during welding of the first side, and if it is not removed it will get into the weld and make it weak and brittle. There are two reasons for this: First, melted steel will dissolve quite an amount of oxide just as water dissolves salt, but on cooling, when the metal crystallizes, it rejects to the boundaries of the grains much of this foreign material, and as it has no strength, the metal is injured; second, if the oxide is present in large enough amounts, it is included in the weld, unless great care be taken to float it to the surface of the metal during the welding, with the same result as before.

I might speak here of the necessity of forcing to the surface all foreign material during welding, as, in my opinion, this is an important source of defective welds. Another difficulty, which is really the same thing, is allowing melted metal to run over on to metal that has not been fused. As the latter is always covered with a coat of oxide, the result is a weak spot in the weld. It should also be noticed that the thicker the material being welded, the more liability there is of any or all of these defects occurring, and this is one reason for my belief that we should not, at the present time, attempt to use material of a greater thickness than ⅝ inch for making fusion-welded pressure vessels.

Regarding the thickness of material, it should be noted that a single "V" weld in material ⅝ inch thick, using a 90-degree "V," is 1¼ inches wide. It is not possible to protect all this surface at once with the welding flame, or with the gases from the arc, and the very hot metal comes in contact with the air and is coated with oxide. The weld metal has to be remelted more or less, the amount of remelting and oxidation increasing as the thickness increases.

Again, a single "V" weld is seldom welded through, even in the best welding shops, because objection is made to any drops projecting from the inside, for reasons which are sometimes good and sometimes bad. And as it is difficult, if not impossible, to avoid these projections, the welder stays away from the sharp edges of the "V," which melt away readily, and ball up due to the surface tension of the melted metal. This balling up results in a wide opening at the bottom of the "V," which is hard to fill up. The result of not going through is an unsound weld at the bottom of the "V."

Oxide Cause Rupture

It may not be out of place to say a few words about the bearing of oxides on the weld strength. I have shown[1] that the path of rupture in steel fusion welds is first initiated as visible inclusions. If there are none of these, the next place they begin is at the grain boundaries, even when no foreign matter can be seen there at the highest power of the microscope. This is true in both gas and electric welds. It is known that such welds are over-oxidized, and the inference is fair, I think, considering this and other evidence, that oxides are the cause of the intergranular rupture. It is evident that every effort should be made to keep welds as free from oxides as possible. Tests indicate that the tensile strength of an oxidized weld in ½-inch plate is about 43,000 lb. per square inch. The yield point of the specified base metal would be something over 25,000 lb. per square inch, so that there is quite a margin of safety in a poor weld, as far as tensile strength is concerned, even when the weld is no thicker than the plate. It is commercially possible to reinforce a weld 15 per cent on each side, so that its section will be 30 per cent greater than that of the plate. Therefore the tensile strength of a poor weld reinforced would be, referred to the plate section, say, 55,000 lb. per square inch, or more than that of the plate. I therefore concluded that a reasonable reinforcement of the weld is necessary for safety. The above figures are based on the use of straight low-carbon-steel welding wire. If higher-strength material be used, the margin of safety is still greater. For example, the average tensile strength of the special-wire welds referred to is 62,400 and the minimum 58,600 referred to the weld section. A 30 per cent increase would mean an adjusted plate strength of about 76,000 lb. per square inch, which is much higher than the upper limit for ship plate, 68,000 lb. From a design standpoint it is, of course, desirable to use as strong a plate as possible to make the vessel as light as may be. But we must be sure that the plate is always sufficiently weaker than the weld, and allowance must be made for the defects that cannot be avoided in practice.

I would again speak of the danger of assuming a weld value in design that is based on a plate stronger than the weld. Such a value is pure assumption, in spite of tests, because no account can be taken of the unknown strains in the sheet. If, on the other hand, the plate is purposely made enough weaker than the weld, there can be no danger of the weld giving way under any circumstances. If it can be shown that this can be done under usual shop conditions, it would be fair, I believe, to assign a high weld value to such construction. It should be kept clearly in mind that weld values have been in the past taken from welds made on different principles than those here advocated, and that they cannot be applied fairly under the proposed conditions. It is as if a riveted joint could be designed that had 150 per cent of the plate strength. Surely it would not be fair to assign to such a joint an arbitrary efficiency of 70 per cent.

There must be a limit to the tensile strength of a weld, and in my judgment, the margin by which the plate strength should be less than the weld strength, is not known with sufficient exactness to permit of any general statement being made as to its amount.

Lower-Stensile-Strength Material Advocated

Assuming that a weld 30 per cent stronger than the plate is enough to allow for usual defects in the weld, and that such a defective weld will always break the plate, we might assume that we could safely use 65,000-lb. plate, and would be safe if the weld tensile strength were 65,000 lb. per square inch and if it were reinforced 30 per cent. This would be true theoretically, but I am afraid of practical difficulties. The welding strains would not be absorbed by the plate as readily as with softer base metal, and there is doubt in my mind as to the welding qualities of such plate. I am strongly of the opinion that these difficulties are absent in the case of the suggested base metal. Therefore, it seems to me that till such tests have been made as will show beyond question that the use of high-tensile-strength plate is safe, we should use lower-tensile-strength material, which is known to be satisfactory. It is important, however, to determine in the near future the possibilities of higher-tensile-strength material than that specified.

One precaution that should always be taken for important work is the rerolling of the shell after it is welded. The reasons for doing this are that it is impossible, particularly with heavy sheets, to roll them truly round at the ends, and the flat spots that are left there are liable to cause trouble when the vessel is put in service, due to its tendency to assume a circular section under pressure. This puts a bending stress on the weld which it is not well suited to resist, while if the shell is rerolled, the strain becomes tensile. Further, it tends to relieve the welding strain, if not to entirely remove it, and to locate defective welds.

Relieving Welding Strains

The question of annealing pressure vessels after welding, in order to relieve the welding strains, is one about which not much is really known. It would seem to depend partly on the thickness of the sheet. The thin sheet will readily distort during the welding and relieve the welding strains, while a thicker one will not do this so easily. This is another reason for limiting the thickness of the material. Another thing that influences the strain is the diameter of the shell, as a large shell will accommodate it-

self to the strain more readily than a small one of the same thickness.

The annealing of a pressure vessel may mean several things: First, heating of the weld and its vicinity to a sufficient temperature to relieve the welding strain. Second, the annealing of the weld metal to reduce the grain size to make it more ductile. Third, the annealing of the metal next to the weld to remove the coarseness of the grain produced by the welding heat. There may be also, combinations of any two or all three of these treatments. It should be clearly understood, however, that the temperatures for the three treatments mentioned are entirely different. The temperature for relieving the welding strain does not need to be more than a very dull red, say not over 900 degree Fahr., and even this may not be necessary, as is shown by the fact that many cast iron pieces are welded successfully without being heated to a dull red.

The refining of the grain in the base metal requires a higher temperature, which must be above the upper critical or Ac_3 point. This temperature varies with the chemical composition of the steel, particularly as regards its carbon content. This temperature for the steel specified in this paper is about 1,525 degrees Fahr.

The chemical composition of a weld varies not only with the composition of the welding wire, but also with the method of its making. However, a gas weld made with ordinary straight-carbon-steel wire has a very low carbon content, not much over 0.04 per cent, and for forged material, steel of this composition would have an Ac_3 point of about 1,625 degrees Fahr.

It is well known, however, that a casting requires a higher refining temperature than a forging of the same chemical composition, and by test I have found that a gas weld made as described has a refining temperature of about 1,750 degrees Fahr.

In an electric weld made with bare wire, there is a large percentage of nitrogen, in some cases as high as 0.14 per cent, while the other elments are usually present approximately in the same proportions as in a gas weld.

The presence of nitrogen entirely changes the critical points, and in the case of such a weld they appear to be absent. This does not mean that the structure of an electric weld cannot be altered, but it does mean that the temperature would have to be determined by experiment.

In the case of nickel-steel welding wire, the weld contains over 2½ per cent of nickel. Nickel lowers the upper critical point, depending on the amount of nickel present—in this case, about 50 degrees Fahr.

It will therefore be seen clearly that annealing for any purpose except relieving the strains is impossible from a commercial point of view, as it would involve a double heat treatment.

It is evident that it is not necessary to heat the whole vessel for the purpose of relieving the welding strains, and probably a dull red heat for a distance of 2 or 3 inches on each side of the center line of the weld in ½-inch material would be sufficient.

It is doubtless true that either annealing and rerolling can be omitted in some cases, and that neither of them would be required for safety in other cases. But it seems clear that the higher the tensile strength of the plate, the greater the necessity of taking these precautions. A further reason for using low-carbon sheet is that it is not liable to be injured by the welding heat as much as higher-carbon material.

It may be objected that the carrying out of these principles will be so expensive as to make it commercially impossible to use fusion welding for pressure vessels. There are two answers to this. First, the burden of proof of the correctness of the statement rests on those who make it, and until proof is given of its correctness, the mere assertion is not evidence. Second, if it be true in any case that safe practice (and this does not of necessity include all the precautions mentioned for every case) makes welding too expensive, then it is obvious that welding cannot be used.

Further, there is involved the matter of salesmanship. If we believe that a properly welded vessel is better and safer than a riveted one, we should be able to sell it in all cases where it is worth the price, and if it were not worth the price, we could not honestly urge its installation.

It is quite possible that poorly welded pressure vessels are much cheaper than well-riveted ones, and that this has been used as a means of reducing prices in some cases. But if this be true, those responsible for the poor welding cannot come into court with clean hands, and their arguments would be invalid. Fortunately, such arguments are rarely heard, but unfortunately we must make specifications which guard against such possibilities.

Welded Vs. Riveted Tank

It may be of interest to consider the relative merits of welded and riveted tanks as far as strength is concerned. Only one instance will be given. Assume the riveted tank to be double lap riveted of ½-inch plate of 60,000 lb. tensile strength, and 5 feet in diameter. With a factor of safety of 5 it would be good for 140 lb. working pressure by the usual formula. If the welded tank were of the same dimensions of 50,000-lb. plate with a weld strength of 125 per cent of the plate, which is easily obtained, it would be good for 141 lb., if a weld efficiency of only 85 per cent were assumed, using the same factor of safety and formula. I really believe that the welded vessel is far superior to the riveted one in this case, in every way.

Objection has been raised to the use of welding because of the small resistance of welds to alternating stresses and shocks, to which any pressure vessel is subject in service. It is true that if the base metal is stronger than the weld, the weld readily gives under such stresses, but it does not seem to be so if the base metal is weaker.

In order to determine whether the ideas which I held were correct, a number of welded plates were tested and then later further tests of actual pressure vessels were conducted. The complete results of both sets of tests are presented in the appendices to this paper.

Also through the courtesy of the Quasi Arc Weldtrode Co. a number of tests were made in their Strohmenger alternating bending impact machine, especially designed for testing welds. The test piece, ⅜ by 2½ inches in section, with the weld machined flush with the base metal, is clamped in the jaws, with its edge level with the center of the weld. The vibrating head is loose on the test piece, the opening being ½ inch wide. The head travel is so adjusted that the test piece bends 5/32 inch on each side of its central position, so that the travel before impact is ⅛ inch and the total bend 5/16 inch. The number of alternations is about 600 per minute. Of course, no quantitative results can be obtained, but the results were quite consistent in the forty-two tests made.

One set of tests was made with two welding wires, an ordinary low-carbon steel, and 3.5 per cent nicked steel. Two base metals were employed and 3 test pieces were made with each combination, a total of 12. The results of this series were as follows:

Base metal	Welding Rod	Average No. of Alternations Before Rupture	Broke
57,000 lb. tensile strength bar steel,	Carbon steel	3300	all in weld
57,000 lb. tensile strength bar steel,	Nickel steel	5600	all in weld
47,000 lb. tensile strength plate,	Carbon steel	4550	all in weld
47,000 lb. tensile strength plate,	Nickel steel	8550	all out of weld

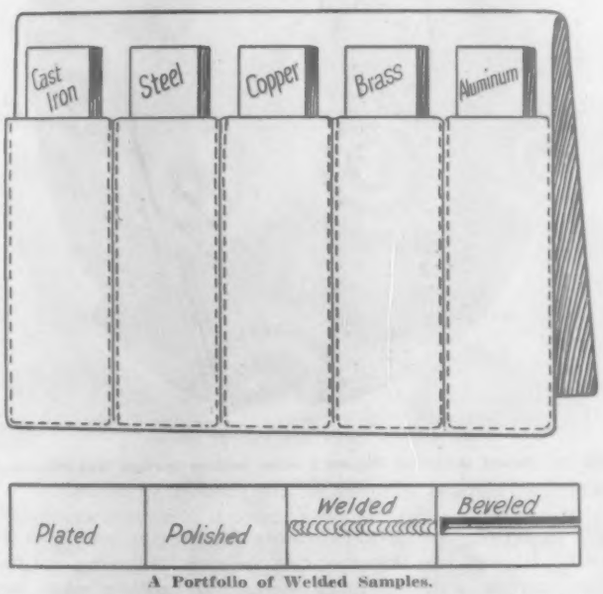
These results show clearly the superiority of the low-strength-plate-high-strength-weld combination. It might be said that the unwelded plate gave about the same results as the nickel steel welds.

It seems clear that the stiff nickel-steel weld threw the strain into the soft plate, which broke just next the weld in the zone coarsened by the heat, and if this zone has about the same resistance as the solid plate, as the tests indicate, there can be little

fear of danger from alternating stresses in service, in a vessel made in the same way. It should be remembered, however, that the higher the tensile strength of the plate, the higher the carbon content, and therefore the greater danger from the welding heat, especially if the heat be applied rapidly and the cooling occur quickly. This has resulted in ruptures in heavy boiler plates, say 1 3/16 inches thick, due to the formation of a sorbitic zone next the weld, and to the strains set up in the sheets by the weld shrinkage. This trouble can be avoided by preheating sufficiently to avoid forming sorbite, which requires a rather rapid rate of of cooling for its formation. This sorbitic condition would doubtless have an effect on alternating stress tests, and such tests should be considered a necessary part of any program for studying the value of plate for welding purposes.

A SUGGESTION FOR WELDING SALESMEN

"How do I know you can weld?" "How does a welded job look when it is finished?" "Can you weld cast iron?" "brass?" "aluminum?" "Does a weld really hold the pieces together?"—and so on; the prospective customer asks question after question. The salesman must answer them, and very often can answer them positively, but his answers are hard to prove. If the prospect has been stung on previous welding jobs, photographs don't help a great deal. He has seen good looking jobs which proved to be failures. He wants to get below the surface and see what the joint actually is. The salesman cannot carry a whole welding shop around on his back, and the prospect may not be interested enough to go to the shop and see for himself.



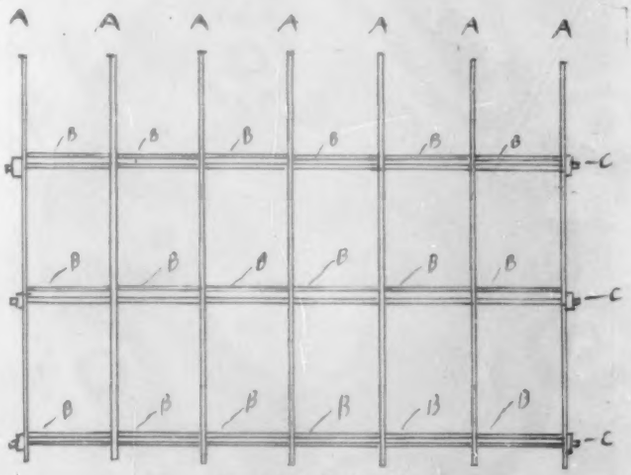
A Portfolio of Welded Samples.

"What to do" in a case like this. Mr. A. D. Lansing, proprietor of the Lansing Welding Co., of Chicago, Ill., has devised an ingenious method of "sampling," which is illustrated in the accompanying sketches. A heavy leather carrying case contains five welded strips, each in a separate pocket. The different metals used are: cast iron, steel, copper, brass and aluminum. The strips are about 5x1x1¼ inches, the weld running longitudinally through the strip. Each one shows four distinct conditions: (1) the metal bevelled for welding; (2) the finished weld; (3) the weld ground down to a smooth surface; (4) the welded portion nickel-plated. The pockets are just deep enough so that only the nickel plated ends of the specimen welds can be seen when the case is opened, and of course they all look alike. They can be pulled out an inch and the prospect invited to locate the welded area in the smoothed area. This is a good demonstration no matter whether he is familiar enough with metals to spot the weld or not. Finally all of the pieces can be pulled out and turned over for inspection, as samples of what can be done with the torch or the arc. Of course a first class pessimist can cite a variety of reasons why this little outfit doesn't prove anything, but a reasonable man would certainly be impressed favorably by a set of sample welds handled this way. It is small enough to carry in the pocket, yet complete enough to create a "welding atmosphere" wherever it is shown. The use of the small samples overcomes one of the greatest obstacles in selling the service of the welding shop, that is, the fact that such service is rather intangible. Give the buyer something to play with and he feels a little better acquainted with the proposition.

WELDING ROD RACK

Every welder knows the inconvenience and loss occasioned by the lack of a suitable method of keeping the various kinds and sizes of welding rods separate. The accompanying sketch represents a simple, easily constructed, inexpensive rack for this purpose. The size can be varied to suit each individual need.

The uprights marked A are made of steel, approximately 1/16 inch thick, the grade used for smoke stacks is suitable, this stock being cut in pieces from 13 to 15 inches wide by 36 inches long, the number of upright pieces used varying according to the number of divisions desired.



Convenient Rod Rack.

The strips marked B are made of number 12 gauge band steel, 3½ or 4 inches wide by 36 inches long. The 3½ inch width makes a very satisfactory division but the 4 inch will give somewhat greater capacity. The rods marked C are made of ¼ inch steel threaded on each end and of a length suitable to clamp the uprights and supporting pieces together. This rack may be placed upon suitable supports under the welding table where it will occupy space which otherwise would be wasted.

A. E. F. CORPORATION EXPANDING

The American Electric Fusion Corporation, Chicago, Ill., recently increased its capital stock from $30,000 to $40,000 and chose the following officers: E. J. Henke, re-elected president; A. B. Sonneborn, vice-president ,and G. F. Strand, secretary and treasurer. Mr. Strand is a new man in the organization and was formerly president of G. F. Strand & Co., machinists and pattern makers, 315 South Clinton Street, Chicago, Ill. When his shop was recently destroyed by fire, he joined the American Electric Fusion Corporation forces and will have charge of the manufacturing end of the business. The company has bought the complete equipment of the Picturola Corporation, and has moved its plant to 972 Montana Street, where with 8,000 ft. of floor space, it will have six times its previous manufacturing capacity. The company's business has increased from 300 to 400 per cent since a year ago. In the near future, it will introduce on the market three new types of machines, including a small spot welder and a seam welder.

WELDING IN THE TIRE INDUSTRY

How the Electric Arc Serves Rubber Tire Manuiacturers by Reclaiming Broken Molds

By A. M. Candy*

IN the process of manufacturing the casings for pneumatic rubber tires such as used on pleasure, and some commercial vehicles, the tire proper is built up to the proper form, after which it is inserted in a large mould of the proper size, and having the proper design worked out on the inside of it to produce the desired configuration of the tire tread. The general appearance of such a tire mould is illustrated by Fig. 1. It will be observed from this illustration that the mould is constructed in two halves provided with lugs around the outer edge so that the two halves of the mould can be held together by bolts, each having a T head. One face of these moulds is a plain surface, as indicated by the front side of the mould, whereas the reverse face of the other half of the mould contains grooves so that a circulation of steam can be obtained when the moulds are placed in the vulcanizers. These moulds are subjected to very rough mechanical handling by the class of labor which load and unload the moulds into and out of the vulcanizing tanks. The vulcanizing tanks are usually constructed below the floor level, and contain a circular table operated by a hydraulic ram over the top of which a convenient chain hoist is located so that the moulds can be readily lifted and moved over the table. Approximately twenty of these moulds are piled one upon another on the circular table, which is gradually lowered as the various moulds are placed in position. After the last mould has been loaded on the pile of moulds the lid is placed on the vulcanizer and secured in position. The hydraulic ram is then again lifted until the pile of moulds is thrust against the top of the vulcanizing tank, which relieves the bolts holding the halves of the moulds together from most of the strain. The next operation is then to turn live steam into the vulcanizer, which circulates around all of the moulds and in between the moulds through the grooves in the face of the halves of the moulds. This steam is approximately at 50 pounds' pressure. The moulds are kept in the vulcanizer under this steam pressure for a period of 4 to 7 hours, depending upon the size of the tire being made. At the end of this time the steam is turned off and cold water is turned into the vulcanizing tank to arrest the vulcanizing action, and to reduce temperature of the mould, so that they can be removed and handled immediately without discomfort to the workmen. The workmen operate very rapidly in removing the moulds and in prying them open to remove the tires as quickly as possible. It is obvious therefore that the cycle of heating and cooling, together with the rough mechanical handling which these moulds receive, results in a very large amount of breakage. Furthermore, the alternating heating and cooling cycle gradually causes the cast iron to crack and fail. The average life of a good tire mould is estimated at approximately 60 to 70 heat cycles.

Fig. 1. Tire Mould rendered useless on account of severe damage received in service.

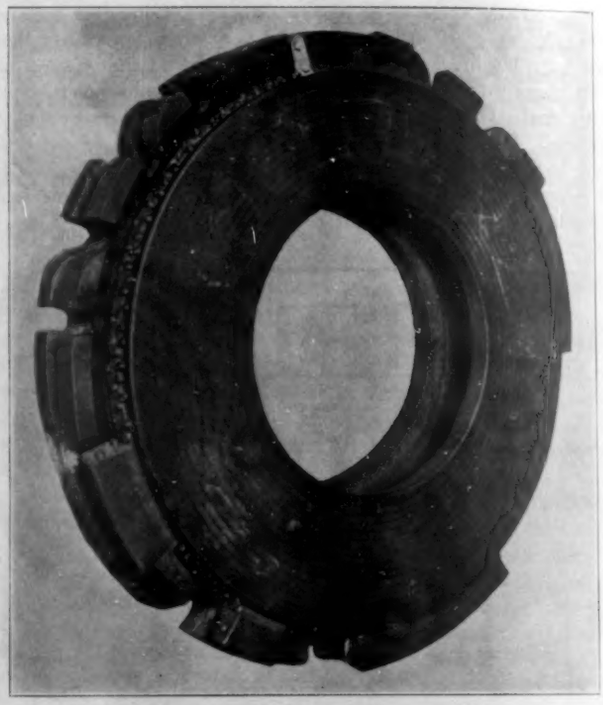


Fig. 2. Mould shown in Figure 1 after broken portion was cleaned off and prepared for welding.

A mould which has been damaged severely in service and which would ordinarily be ready for the scrap pile is indicated by Fig. 1. It will be observed that the greater portion of the lifting lugs have been broken from the half of the mould on the side toward the observer. To properly repair this mould the surface at the broken portion of the casting was thoroughly cleaned off and a series of holes located on approximately 2 inch centers were drilled and tapped for inserting ½ inch diameter bolts. Ordinary machine bolts were then turned into these holes and cut off approximately ¼ inch above the surface of the cast iron, as indicated by Fig. 2. The next step in the operation was to prepare pieces of steel which could be substituted for the missing lugs, said pieces of steel being formed in the shape required for the finished lugs. This piece of steel was beveled off along the inner

*Arc Welding Engineer, Westinghouse Electric & Manufacturing Company.

edge so that when it was placed in position formerly occupied by the original lug, the welding operation could be carried on along the beveled edge of the piece of steel and the surface of the cast iron containing the studs. One of these pieces of steel in position for the welding operation is also illustrated by Fig. 2. This mould after being completely welded and reading for service is shown by Fig. 3.

Many of these tire moulds are very expensive, running as high as $700 to $800 each, owing to the large amount of hand work required to produce the intricate design desired for the tread of the tire. For this reason, therefore, when they can be repaired for a fraction of the cost of a new tire mould, the welding operation is very effective and ecoonmical. Especially is this true in view of the fact that the tire mould which is illustrated was put through 170 heats, at which time it showed no indication of failure, and the counting of the number of heats was therefore discontinued.

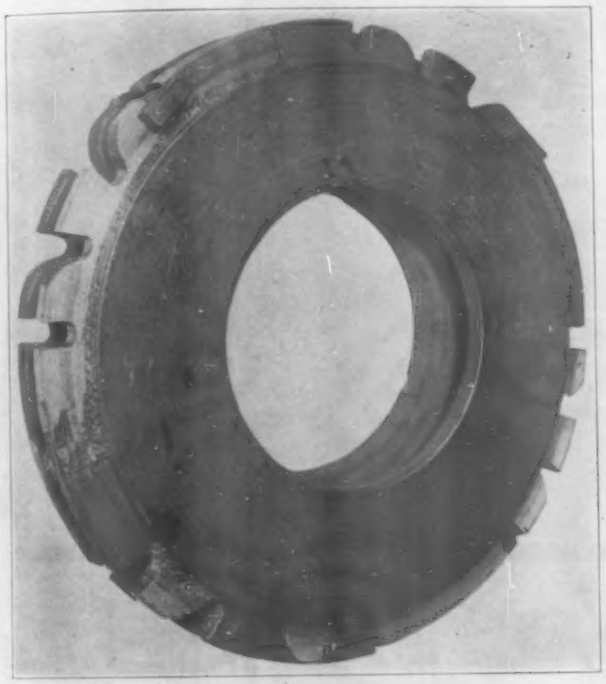


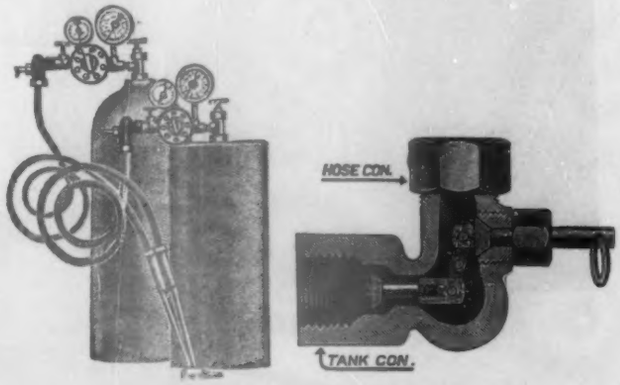
Fig. 3. Tire Mould. This is the same mould shown in Fig. 1, after it had been completely welded and ready for service.

The operations involved and the resulting expense for repairing the mould illustrated is indicated by the following data. It must be borne in mind when going over this cost data that this mould was much more severely damaged than is usually the case. The preparation of the surface of the casting, including the drilling, tapping and setting of the 150 ½ inch studs was approximately 24 hours. Approximately 8 hours were required to form the pieces of steel necessary to replace the missing lugs. Approximately 40 pounds of welding wire were required to do the welding work, the time required for the entire welding operation being approximately 45 hours. The welding time for such work as this is unusually long because it is necessary for the operator to weld very slowly so as to reduce the heat accumulation at any given point to a minimum value, so as to have the cooling strains as small as possible to avoid fracture of the welding work when it is finished. The welding in this case was carried on, using approximately 150 amperes, the total power consumption being approximately 100 kw.-hour. The actual itemized cost of doing the complete job is indicated by the following table:

Preparation of casting, including drilling, tapping and setting bolts, 24 hours' time at 60 cents per hour	$14.40
150 ½ inch bolts at $2.00 per 100	3.00
Steel prepared for replacing lugs, labor 8 hours at 75 cents per hour	6.00
Cost of steel used in lugs approximately	1.75
Welder's time, 45 hours at 80 cents per hour	36.00
40 pounds of welding wire at 8 cents per pound	3.20
100 kw.-hours of power required from supply circuit at 5 cents per kw.-hour	5.00
Grand total	$69.35

A SAFETY VALVE FOR OXY-ACETYLENE INSTALLATIONS

The Mattingly Automatic Valve Co., of St. Louis, Mo., recently announced a safety valve for oxy-acetylene installations, the object of the device being to provide a means for automatically stopping the flow of gas from the tank in the event the hose should burst, or become burned or disconnected from any cause. The illustration shows at the left how the valve is installed between the hose connection and the tank, and at the right a cross section of the valve. The



Mattingly Automatic Valve.

valve is opened by pulling outward on the ring in the end of the stem. This causes the main valve to move off its seat to open position. The manufacturers state that the valve will remain in this position under all operating conditions of the torch until the pressure is relieved beyond the hose connection at which time the valve closes instantly. This principle has for some time been used in the construction of valves for pipe lines and water gauges and has this year been developed for oxy-acetylene welding and cutting apparatus.

"SALLWELD" ASBESTOS PAPER

The Sall Mountain Co., of Chicago, manufacturers of asbestos products, have been supplying a special grade of asbestos paper for welding to the trade through its jobbing connections and recently christened its product "Sallweld." Dealer accounts for this welding paper are being actively solicited.

The Chicago office of the Carbic Manufacturing Co. has moved from 111 W. Washington St. to new quarters at 565 W. Washington St.

The Universal Electric Welding Co., Long Island City, New York, recently moved from 67-69 Sixth Street to 90 Webster Avenue.

The Metal and Thermit Corporation suffered a loss of $50,000 June 24, when a fire destroyed one of the buildings at its plant on Cornelson Ave., Jersey City, N. J

It is reported that the Wheeling Oxygen Co. is planning to erect a new plant for the manufacture of commercial oxygen at Warwood, W. Va.

The REGO TORIT No. 13

Has Hundreds of Money Making Labor Saving Uses for Every Repair Man

HERE is another attractive addition to the well known Rego line of welding and cutting equipment. The Rego No. 13 outfit consists of a torch about ten inches long, weighing only a few ounces, a set of four tips, one of which is made especially long and slim for radiator work and battery repairing, a soldering copper which clamps over one of the tips and which will melt solder within thirty seconds from time of turning on the gas, five feet of rubber hose, and a connection for auto acetylene lighting tank.

With the long tip you can work between the fins of a radiator and solder up a leaking tube without cutting the fins away. With the large tip you can heat a two pound soldering copper in about a minute, or braze a steel bar three-quarters inch in diameter.

A Few of the Many Uses of the Torit Torch No. 13

Radiator Repairing
Heating Rivets
Soldering Tinware
Babbitting
Cast Iron Soldering
Joining Light Tubing
Thawing Pipes
Aluminum Soldering
Soldering Electrical Connections

THE BASTIAN
WEST AUSTIN AVEN

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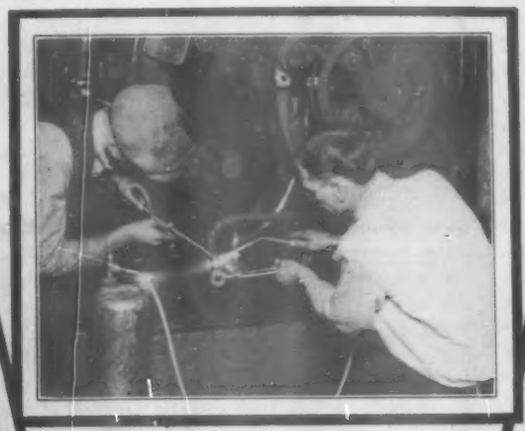
INSTANT HEAT FOR SOLDERING, LIGHT BRAZING, RADIATOR REPAIRING, ETC.

moving Rusty Bolt



Soldering Electrical Connections

Battery Repairing

Soldering Seams

Babbitting Bearing

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BETTER WELDING PRACTICE

Best Ways and Means of Advancing the Art of Oxy-Acetylene Welding from the Place It Now Occupies

Chicago,
Saturday.

Dear Ed:

Had rather an interesting time last night. One of the boys is leaving town for good, so some of the old guard got up sort of a farewell dinner for him. I didn't know anything about it until they called me up. Guess they just learned I returned. Some of the faces were new to me and I didn't get their names, but when you get men like Goodrich, Mackenzie, Austin, Dunham, Mueller, Campbell, Maeurer, Slack, Cook, Macleod, Jardine, Doc Ernest Senhert and as many more together, you may rest assured that someone is going to start talking welding. That's just what happened and I figured you would be interested in hearing about one particular angle that was taken up.

The question arose as to the best ways and means of advancing the art of oxy-acetylene welding from the place it now occupies. You can rest assured that there were plenty of suggestions. (Did you ever see a welder that couldn't do a lot of suggesting?) Taken as a whole, though, they were impractical. Then a new comer got the floor and I thought a few of his points were pretty well put. I couldn't get his whole talk, but here's about the way it ran:

First he went back a few years to show the early applications of the process. How to begin with the apparatus was very costly, as well as the oxygen and acetylene, both of which were quite difficult to obtain. The skepticism that arose at very turn and the necessary demonstration and efforts of the pioneers to obtain a fair trial and hearing for this new and most wonderful method of fusing metals.

Not very much time was spent in dwelling upon the history of the process, but just enough to bring out the point that it was a fight from the beginning. In most every line they were unbelievers and really had to be shown before they'd be convinced. Slowly, but surely, the process kept on growing. More manufacturers of apparatus appeared and very soon traveling salesmen began preaching the gospel. Some of these men became overly enthusiastic at times and in an effort to close a deal would endeavor to show how anybody with the intelligence of a fifteen-year-old boy could set up a welding plant and do good work without any experience, whatsoever. Arguments of this sort may have helped to sell welding equipment, but it did not tend to elevate the status of the process. When plants were sold under these conditions, who did the welding? Skilled welders were not available so the company purchasing equipment would pick out one of its own men. Would this man who was to handle this powerful repair agent and also apply it to manufacturing, be the brainiest in the company's employ? Would he be a first-class machinist or a tradesman of any kind? No, invariably no, for they couldn't be spared. He usually was the "roust-a-bout;" the man who was not a success at anything else.

He went on to explain that like every other rule, there were exceptions to this means of making a welder, but that the majority of companies took men they couldn't use in any other capacity and let them handle the welding. For the most part these men were uneducated and consequently didn't go to books for their instruction, rather, they experimented in the shop and found that after a bit they could join metals in pretty fair shape. Perhaps their advice and help would be sought in the repair of emergency breakdowns about the plant. After one or two successes their estimation of their own prowess would know no limit. In meeting them, they now admit that they are all the oldest as well as the best of all welders and it is quite a difficult proposition to tell any of these men anything at all pertaining to welding.

According to this fellow, all welders should have for their first name "Alibi." It appears that once in a while a weld will fail, but that never bothers the welder; immediately he gives you the reason. Either the metal was of a very poor grade; the "filler rod" not the correct size; the flux poor; his goggles the wrong shade; the gauges were creeping; the tip was the wrong size or somewhat "jimmed," but never under any circumstances is the welder at fault.

Recognizing conditions as they are, something must be done to instill greater confidence in welding if the process is to continue to grow. This is a day of efficiency. How can greater efficiency be obtained in welding? If the finger can be placed on the right spot the question is answered.

Oxygen and acetylene producers; carbide makers; apparatus manufacturers; steel, cast iron, brass and aluminum mills and foundries as well as the customer and welder, all lose out every time a job that can be welded is turned down or a failure made. Realizing this and remembering that this industry, if it may be called such, has already gone through most of the birth pains, should lend added zest in searching for greater efficiency.

Someone suggested that all welders join the unions with which they are closest associated, thereby getting greater cooperation from their fellow workers. In answering this, he pointed out that records showed that this had been tried out in a number of different industries, but it didn't seem to improve the status of welding. Railroads were taken as an example and citations made where the welding standards were lowered many per cent when the welding was taken from under one head and split up among the different crafts. It seemed but natural that if a welder were working on boiler work that he be under the supervision of the boiler shop foreman. Likewise in the blacksmith shop; machine shop, and so on the welder should be working under the different foremen and not under one head for there might be a conflict in having too many bosses on the job. However, in actual practice the railroads have learned that the boss welder idea is the best and many of them are returning to it.

Welding schools for teaching advanced work was next touched upon. He was perfectly frank in stating that in his opinion by far the greater majority of schools now giving welding instruction are not successful. The reason for this he accounted for by showing that in order to give proper instruction, the tuition fees would be exorbitant. In the first place training cannot be all given from text books, oxygen and acetylene must be used. Usually the more gas a beginner burns, the more he learns. A "set-up" of large tanks will not last a student very long, yet the cost will be from twelve to fifteen dollars. Perhaps five or six such "set-ups" will be necessary before the beginner gets even a fair foundation. In many schools the instructors, it seems, receive a very meager salary, ranging from seventy-five to one hundred dollars a month. These men couldn't possibly be well versed with welding or they would be out earning many times this amount doing regular welding, yet we know that it requires a proficient instructor to give the proper training. The subject matter is also a serious problem around schools. The discovery and purchase of the correct material to work upon is another important phase not to be overlooked. Summed

up it could readily be seen that in order to get the right kind of training a fee of one hundred and fifty to two hundred dollars per week would have to be charged to break even. What kind of instruction is therefore to be expected from these schools where the entire fee for welding amounts to ten or twenty dollars?

The school idea was approaching his conception of a solution to the problem of obtaining better work from the present welders. The school affords a wonderful opportunity to both beginners and advanced welders if properly conducted. But there seemed to be another hitch here. How to get the welders to the school was the question. Some time ago a school was opened where any kind of advanced welding could be taken up. The organizers calculated that many employers would grasp the opportunity to give their welders a little better education and in turn do better work for them. However, this school did not last long. Why? Perhaps the reason stated awhile back gave the answer—each welder thinks he's the oldest and best welder and being of the uneducated type, is not far sighted enough to see that he might learn many things if he but opened his eyes. The school did not prove popular, and consequently it closed.

The certifying of welders might insure greater welding efficiency, but that, too, might have its objections, he pointed out. Examining boards would have to be appointed and maintained at available points throughout the country where the welders could be examined and certified as to their proficiency. This, however, would be a practical affair and if carried out would certainly advance the art of welding. But there seems to be yet a better and more satisfactory method to consider. Could not a means be found whereby a welder could be examined in his own shop with all its environments?

The foremen and men overseeing the welding in most shops are not as a rule welders themselves. As a result a solution must be found which will permit their knowing whether each man is producing good sound welds. Assuming that it's quite out of the question to determine by looking at the outside of a weld whether it's a perfect fusion all the way through, another way must be found. There seems to be but one answer; if the parts being welded cannot be tested, then similar welds can be made and given destructive tests. This will show any welder's ability to make good sound welds.

How could this procedure be applied in practice? Simply as follows: In many plants there are a number of welders employed. These men are assigned to different classes of work and it's usually the one who finishes up his work the best who is considered the best welder. This may be all wrong. There may be other men, working on other parts who could make much better welds on the inside than the one who gives the fine finish. They may be more skilled in handling one metal than other. The foreman should know this and profit by it. By having a series of tests, this information is available and better results are forthcoming.

For an example let us assume that we are for the moment in a boiler shop where a number of welders are working. The welding standard wants to be improved or it may be that there is a very particular job coming up where the most skilled operator is required. Now in most shops the oldest man is considered the best welder for very often he teaches the other men all they know about welding, but this does not always prove to be the case. Some men seem to be more given to welding than others. Much like musicians, some people learn to play with very little practice, while others may practice all their lives and never reach their goal. The foreman of this shop, in order to carry out his observations, has some strips sheared off the plate the men are working upon. These strips need only be two and a half or three inches wide and say six or eight long. Two of these pieces are given to each man with instructions to fuse the small ends in the best possible manner. He may take all the time he wishes; can choose whatever torch and tip he thinks best; the work is set up and prepared in any manner with this single exception: The weld MUST be made from one side only. The size of the filler rod, his goggles, etc., are of his own choosing, the idea being to have him work under what he considereds ideal conditions so that there will be no chance for alibies. Even go so far as to explain that after the weld is made it is to be broken and examined for penetration, flaws and uniformity of grain. Being forewarned in this way, a welder should do his best. When the welds are made, they are allowed to cool slowly and then broken over an anvil or in a vise by hammering back and forth. When all the tests have been treated in this way the parts can either be placed on exhibition or the results printed on the bulletin board. What will happen if the oldest welder turns out the poorest weld? Will he not feel ashamed of himself if he possesses any pride at all and hurry down to some shop after hours and practice up? A test of this kind given once a month will actually let the men see the inside of their welds and after examining, they will all strive to overcome their faults and aim for the head of the list. What then would be the results? Simply this: First, the men would become better welders for they could see their faults and correct them. Second, the owner of the shop would be helped because his work would be turned out better. Third, the welding industry would be benefited on account of the higher standards.

In shops where various metals are handled, tests can be made in the same way only using different metals in the monthly tests. In the one-man shop tests of this kind should also apply. Just because a man is boss and welder all in one, is not reason enough for him to assume that his welds are right. He owes it to the industry which helps him to live, to help elevate its standing. It's the inside of the weld that really counts and every man handling a welding torch should thoroughly appreciate this fact.

In winding up his talk he laid special stress on the help that the traveling salesmen and representatives of the many firms interested, directly or indirectly, in the welfare of the oxy-acetylene industry could give in lifting up its standard and extending its application if, in the terms of the vernacular, they would be instructed to cut out the bunco and tell the welders in plain English just how they can forge ahead and produce better welds.

Gee, Ed, I had no idea when I started, that this would take so long to tell. Had I known, I might have picked up a stenographer some place and dictated it. You know it's no effort at all for me to talk. You know me, Ed, I can talk just as fast as the other fellow and some times just a little bit faster. I'll now ring off.

Kindest regards,

Shep.

BLACKSMITH SUPPLY MEN TO MEET IN CHICAGO

The 1922 convention of the International Railroad Master Blacksmiths' Supply Men's Association will be held at the Hotel Sherman, August 15 to 17. Welding by the electric, gas and thermit processes is one of the subjects in which this association is interested.

GAS PRODUCERS TAKE HOLIDAY

The annual summer meeting of the Gas Products Association is scheduled to be held on July 17-20, at Mackinac Island, Upper Michigan. The members will meet at Chicago and start the party by enjoying a twenty-four hour boat trip on the S. S. Manitou. Convention headquarters will be at the Grand Hotel.

The Welding Engineer

Reg. U. S. Pat. Office.

Published on the 17th of Each Month by

THE WELDING ENGINEER PUBLISHING CO.,

608 S. Dearborn St., Chicago, Ill.

Telephone Wabash 7134.

L. B. Mackenzie.....President and Editor
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Subscription payable in advance and postage free.
United States and possessions and Canada.....$3 a year
Foreign Countries ..... 4.00 a year
Single copy, domestic .....25 cents
Single copy, foreign .....30 cents

Entered as second-class matter January 20, 1916, at the postoffice at Chicago, Illinois, under the act of March 3, 1879.

The Welding Engineer is a member of the Audit Bureau of Circulations and of the Associated Business Papers, Inc.

Last Advertising forms close at 8:00 a. m. on the 15th. To show proof for correction copy must be received at an earlier date and allowances should be made for delay to mails.

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EASTERN REPRESENTATIVES
Ben-Hill Co., 14-16 Vanderwater St., New York
Telephone: Beekman 3415—3416

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Possibilities of Better Testing.

TESTING welds by electrical and magnetic apparatus has recently been accomplished on a small scale, with a probability that such apparatus can be improved and further developed to the point where such tests can be made to supplant the present-day destruction tests. A device which would enable an inspector to test the entire length of a weld without injury to the parts would put welding on an entirely new footing. Attempts are being made to perfect such a device, and such attempts deserve encouragement. The only real test available at present is the service test, because tests on specimens are not positive indication of what the total welded production is worth. X-ray Testing is another possibility of great promise which has not so far progressed beyond the laboratory stage. The latter method, by the way, seems to have received more attention abroad than in America.

The Micro-Photograph.

PICTURES which look like bird's-eye views of a dish of scrambled eggs turn out to be photographs of tiny metallic surfaces, magnified a hundred times. They are the best object lesson the welder can find, for they take him down to the heart of the weld and show him that things are going on which he cannot possibly see with the naked eye. Surfaces which appear to be closed turn out to be full of small cracks and metal which he thinks is clean is discovered to be fairly peppered with impurities. The microscope backs up the instruction book at every step, showing in a convincing manner the results of good and bad welding practice, the effects of heat treating and hammering, and the nature of the metal at any desired spot. It tells the welder more about his work, in fact, than he can learn with the same degree of certainty from any other source. It doesn't lie; it is more apt to reveal falsehoods.

The Tales Men Tell.

IT is usually difficult to pass fair judgment on a manufacturing plant at long distance. Men come and go and spread stories of their own impressions and impressions are apt to be biased. Take a big welding plant, for example. The complaints of men who have left it might easily lead a third person to believe that a deplorable state of mismanagement existed. But along comes a workman who left of his own accord, with a good "character," and says it is the best place he ever had—because they supplied clean metal to work on and gave the operator a chance to make sound welds throughout the day. It is pleasant to listen to this sort of talk because it's optimistic. The welder who is looking for a job will have a better chance of finding one if he leaves his hammer at home.

How Do You Charge the Transient Customer?

THIS is the Summer that Pa decided to motor across the country with his family and spend his vacation on Uncle Joe's farm. He strikes a mean stretch of road a few miles from your shop and limps in with a broken frame. When you notice from his license plate that he is three hundred miles from home and at your mercy, how much are you going to charge him for an hour's welding? All you can get or all you ought to get? If you charge him five dollars too much and he knows it (and he usually does) don't you think he can do five dollars' worth of harm to the welding industry? The welder who charges a fair price for the job, with his usual profit attached, doesn't really lose any money. The biggest thing he loses is a chance to get one man sore on the whole welding proposition.

Read on this page, from issue to issue, a description of the features which have made Prest-O-Lite a national institution

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THE SCIENTIFIC SIDE OF WELDING

Resistance Welds—Contact Welding—Spot Welding—Welding Wire for Iron and Steel—Material to be Welded

By E. A. Atkins†

(Concluded from the June issue)

BEFORE examining the structure set up in cast iron welds, it will perhaps, be as well to start with a structure of ordinary cast iron; this is shown in Fig. 41. The light areas show the iron-silicon portions with black flakes of graphite running through them; also there will be seen some pearlite areas containing the combined carbon, and surrounding these the network which contains the phosphorus.

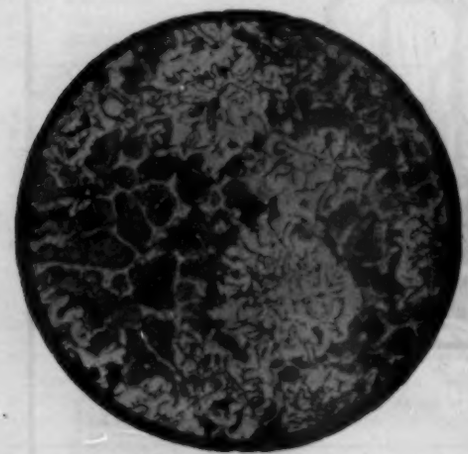

Fig. 41. Cast Iron.

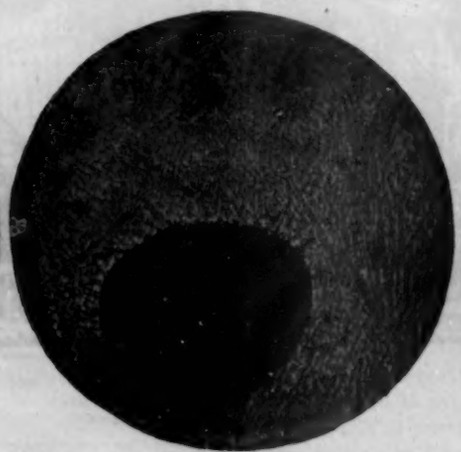

Fig. 42. Arc Weld in Cast Iron Showing Blow-hole.

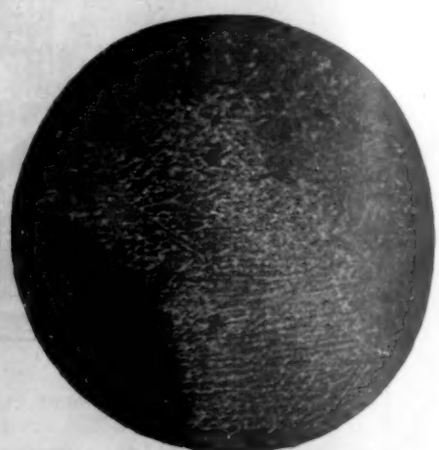

Fig. 43. Arc Weld in Cast Iron Showing carburised metal.

Fig. 44. Arc Weld in Cast Iron Made With Mild Steel Filling.

The structure of an arc weld made in cast iron is shown in Fig. 42, and on this will be seen a large blowhole in the filled-in portion, manifestly caused by the gases formed through the carbon being oxidised. An edge of the blow-hole is shown in Fig. 43, and this micro-photograph also explains why the arc-welded cast iron becomes so intensely hard, as the white network structure on the edge of the blow-hole is composed of the hard carbide of iron, caused by the carburising of the cast iron through the graphite going into solution. This intense hardening of cast iron in arc welding is one of the problems which has to be dealt with and, no doubt, can be solved by the use of a suitable flux under proper conditions. The junction of a weld made in cast iron with a mild steel filling by the arc system is illustrated by Fig. 44. In the micro-photograph it will be noticed that complete fusion has taken place at the joint line, but here again, unfortunately, the mild steel has become highly carburised through the taking up carbon from the cast iron.

In the welding of cast iron the oxy-acetylene process up to the present certainly shows many advantages, as by this process almost complete homogeneity at the junction can be obtained, this being brought about by the use of a highly siliceous cast iron, the silicon performing the very useful purpose of keeping the graphite from going into solution and thus forming the hard cementite. Unfortunately, the use of this kind of filling material in the arc system results in the silicon being rapidly oxidised away. To show how uniform a structure is obtained in an oxy-acetylene cast iron weld the micro-photograph, Fig. 45, has been prepared. In this it will be observed that there is not a great deal of difference in the material on either side of the junction line.

Resistance Welds

Butt-resistance welds can be made under suitable conditions in all kinds of steel. In Fig. 46 the junction is shown of a .80 per cent and a .10 per cent carbon steel welded together. Through the rapid cooling it will be observed that the .80 per cent carbon on the right hand shows the martensitic structure, which means that in this condition the bar on bending would break on the right hand of the joint. Careful annealing will restore the material to its proper tough condition and the remarkable change of structure that follows from this process is shown, of the same joint, in Fig. 47. On the left of the junction

**Lecture delivered at a general meeting of the British Acetylene and Welding Association, on Thursday, September 22, 1921.*

†General Works Manager, Messrs. Rylands Brothers, Ltd., Warrington.

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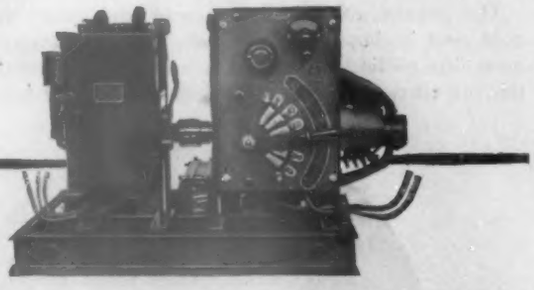

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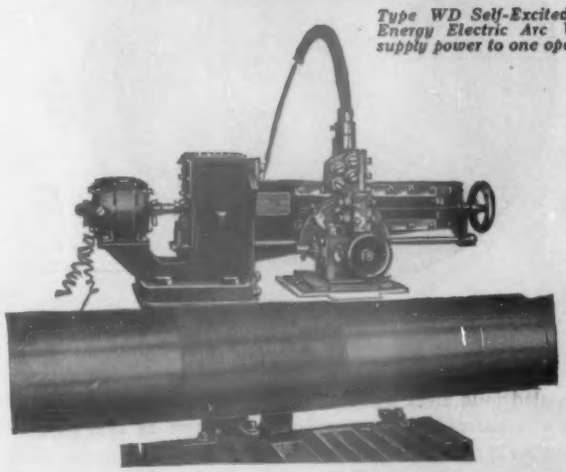

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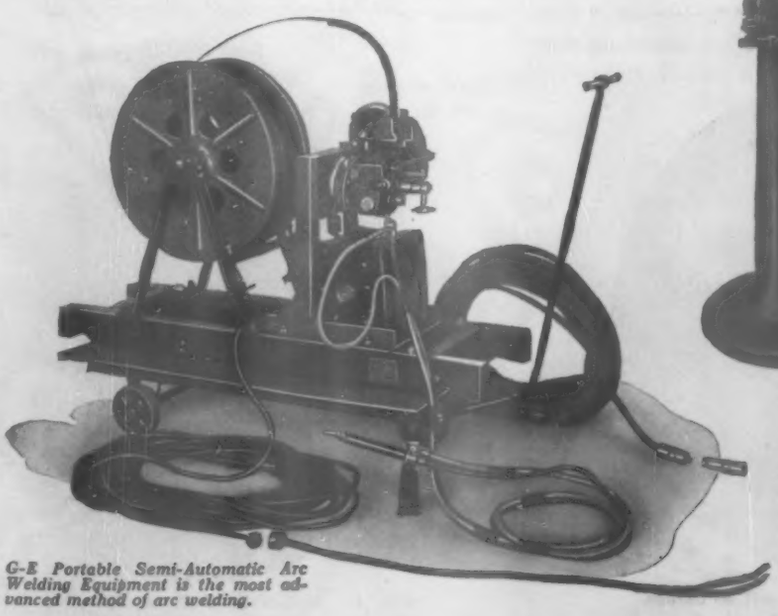

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of this micro-photograph the low carbon steel will be seen in its normal condition, and on the other side of the junction the .80 per cent carbon steel is shown in the pearlitic condition.

The junction of a resistance weld made with two pieces of mild steel is shown in Fig. 48, the fusion in this case being so good that no line of junction is visible, the grain size is large, this, of course resulting in hardness. The same joint after annealing is shown in Fig. 49, giving the characteristic structure of an annealed mild steel without showing any definite joint line, quality of the material being practically the same as that of the steel before welding.

Fig. 45. Acetylene Weld in Cast Iron.

Foreign matter will sometimes get into the junction of a butt-resistance weld and upset its qualities, thus if the ends of a bar are badly rusted the oxide may not be completely squeezed out, and, if not, shows up as the black patches in the micro-photograph, Fig. 50. Perhaps one of the worst elements to be associated with welding is tin, as at the high melting point of steel this element rapidly combines with the iron and forms a hard compound, this is particularly shown in the micro-photograph, Fig. 51, being that of a resistance weld made on tinned-bar steel. In the micro-photo it will be observed there are black and white areas. The white areas show the hard-tin-iron alloy. That this compound is very brittle will be seen by the fracture shown on the micro-photo, Fig. 52, where the grains of iron are separating when the bar is slightly bent.

Contact Welding

Contact welding, in which rods and wire are welded together by simple cross contact to form fabric for reinforcing and other purposes, is now very common, and occasionally peculiarities develop in connection with same. With low carbon steel of about .10 per cent there is no difficulty as this gives a perfect weld at the junction, as will be seen by the micro-photograph, Fig. 53, but when the material gets up to about .20 per cent carbon, brittleness is set up in the wire or rod material adjoining the weld. The cause of this is plainly observed in the micro-photograph, Fig. 54. The white centre portion shows the junction from which the carbon has been oxidised, whereas on the areas immediately adjoining this the martensitic structure is shown, thus setting up great hardness in the material which inevitably causes fracture. Also high sulphur and high phosphorous have a deleterious effect both in contact and resistance welding, the amounts of these elements, however, which cause defective welding vary with each other and with the carbon element.

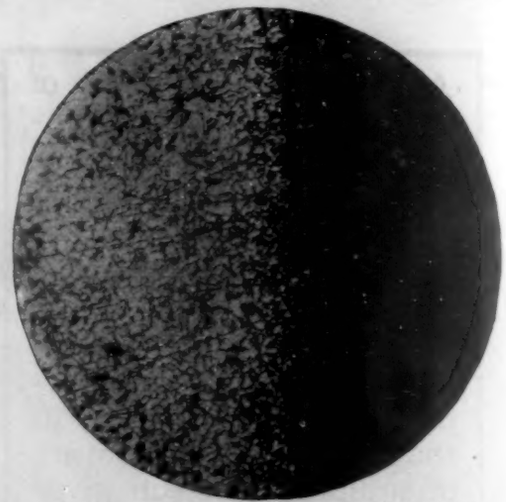

Fig. 47. Resistance Weld of .10 and .80 Carbon Steel Bar After Annealing.

Fig. 46. Resistance Weld of .10 and .80 Carbon Steel Bar as Welded.

Spot Welding

Spot welding is now so commonly carried out that, perhaps, it will be of interest to show what takes place in the metal when two pieces of sheet are welded together. This is seen in the micro-photograph, Fig. 55, representing a section of a "spot" on two pieces of 16 gauge iron. Only a part of the welded zone is shown on which it can be seen that a small blob of oxide has been imprisoned in the centre, due to the scale on the metal, and also it will be noticed that there is a definite elliptic zone within which the structure of the metal has been affected by heat diffusion.

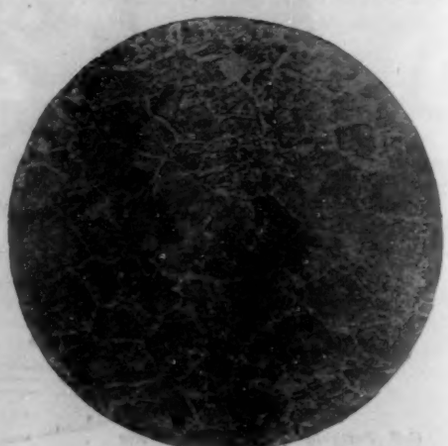

Fig. 48. Resistance Weld of Two Mild Steel Bars as Welded.

Welding Wire for Iron and Steel

As there is so much discussion as to whether Swedish charcoal iron is better or worse than mild steel, it will be interesting to observe the difference between the two structures of these respective materials when they both have the same chemical composition.

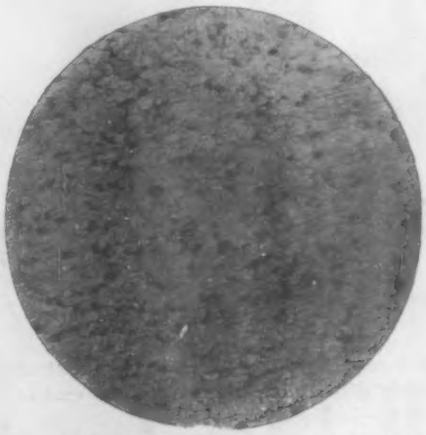

Fig. 49. Resistance Weld of Two Mild Steel Bars, annealed.

The micro-structure of Swedish charcoal rod is shown in Fig. 56, on which the grains of pure iron, together with not only a slag thread, but small blobs of same are visible. Fig. 57 is a good mild steel feeding wire, and on this, while there is practically an absence of slag, there are one or two small dark areas of pearlite which, as has previously been mentioned, contains whatever carbon is present in the steel. A little reasoning will show that charcoal wire cannot possibly have any advantage over a very low carbon mild steel, but rather, perhaps, through the absence of slag, the latter material would be the better of the two for the purpose.

High percentage of sulphur in feed wire is always a disadvantage, as this element is usually found in the steel in the form of globules or threads of sulphide of manganese, as shown on the

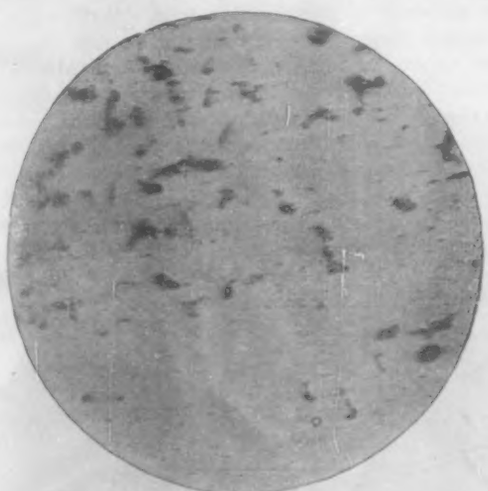

Fig. 50. Resistance Weld Containing Oxide.

micro-photograph, Fig. 58. These sulphides melt at a considerably lower temperature than that of the iron, and, consequently, when the high temperature of the weld is attained the sulphides are in a condition of boiling and so cause sputtering of the metal. This is also true of a high phosphorus content, and as this element as a phosphide of iron is very often in a segregated form, as shown by the white areas on Fig. 59, the same low temperature effects as with sulphur is obtained, in addition to the fact that phosphorus can only be eliminated by special means, and if not so removed causes brittleness of the joint.

A defect in filling wire which is not generally known is the inclusion of enormously large numbers of small specks of slag or oxide in the steel; these are particularly well shown by the micro-photograph, Fig. 60. On counting the number of specks on this photograph it should be remembered that they are on an area one hundredth part of the diameter of the photo circle. Measurement and calculation have shown that some feed wires will have as many as 140,000 of these specks to the square inch, and in

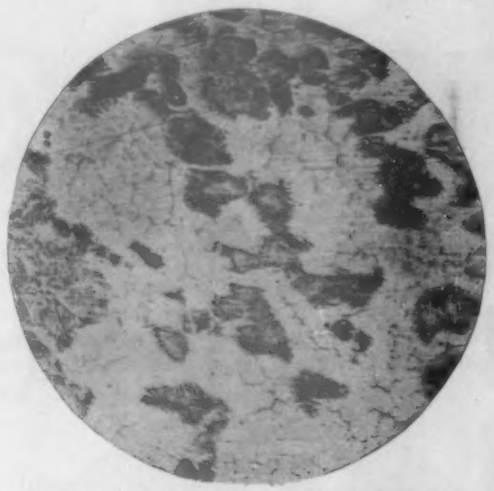

Fig. 51. Resistance Weld of Tinned Iron Bars.

some steels examined it has been calculated that they contain no less than 50 millions of these small globules to the cubic inch. These specks of slag or oxide will, of course, melt at a much lower temperature than the steel, and will, therefore, cause a serious disadvantage in various forms of welding.

A good deal of experimental work has been done to find out the changes which take place in the composition of the deposited material after passing through the arc in electric welding, and so that the issue would not be confused it was arranged that the feed wire should have the same composition as the material upon which it was deposited. Results of a group of these experiments are tabulated below:

CHANGES IN CHEMICAL COMPOSITION OF MILD STEEL FEED MATERIAL AFTER ELECTRIC WELDING.

	A		B		C		D	
	Wire.	Weld.	Wire.	Weld.	Wire.	Weld.	Wire.	Weld.
Carbon	.08	.030	.69	.040	.71	.060	.10	.04
Silicon	Trace	.010	.081	.030	.17	.16	.082	.018
Sulphur	.009	.006	.044	.019	.029	.018	.032	.006
Phosphorus	.012	.010	.068	.016	.062	.043	.018	Trace
Manganese	.12	.028	.61	.14	.84	.16	.60	.17
Nickel								

	E		F		G	
	Wire.	Weld.	Wire.	Weld.	Wire.	Weld.
			(Silicon Steel)		(Manganese Steel)	
Carbon	.11	.04				
Silicon	.16	.09	4.2	2.60		
Sulphur	.017	.022				
Phosphorus	.057	.048				
Manganese	.74	Trace			11.64	9.47
Nickel	3.29	2.0				

In the welds A, D and E it will be observed that about 60 per cent of the carbon has disappeared from the feed material in being deposited. In B and C, where a high carbon wire is used, it will be noticed that about 90 per cent of the carbon has disappeared, which shows that the use of a high carbon wire under certain conditions has very little advantage over that of a low carbon material in the resulting deposit. The removal of the silicon is somewhat erratic; in some cases a large percentage has been removed and in other cases very little. With regard to the

Fig. 52. Resistance Weld of Tinned Iron Bars. Showing Fractures.

Fig. 55. Spot Weld in 16 Gauge.

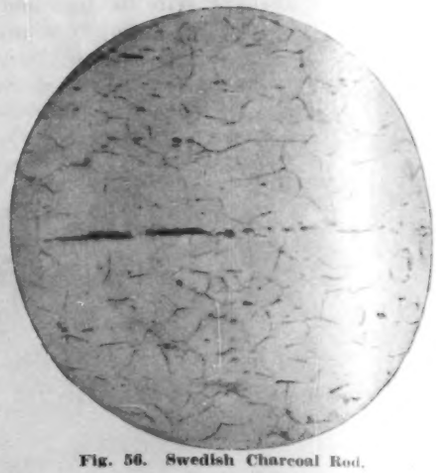

Fig. 56. Swedish Charcoal Rod.

alteration in the amounts of sulphur and phosphorus, it will be seen that in weld A, which was carried out with an ordinary flux coated electrode, there has been very little alteration, but examination of the sulphur and phosphorous contents in welds B. C and D show that there has been a remarkable reduction of these elements in the weld material in all three cases. This, it might be explained, was brought about through the use of a special, what might be called, anti-sulphurphos flux.

Fig. 53. Contact Weld of .12 Carbon Steel Rod.

With regard to manganese, it will be seen that all the welds of the top table show a loss of about 75 per cent of the initial manganese in the feed wire.

Tests have also been carried out on one or two cases of special steel, and the results tabled for weld E show that where a wire containing about 3¼ per cent of nickel had been used, about one-third of this disappeared in the welding process, whilst, rather singularly, practically the whole of the rather high (.74 per cent) manganese disappeared. Tests with a steel containing 4¼ per cent of silicon gave results of no particular value, except as showing that about 40 per cent of the silicon disappeared in the process. Tests with steel containing about 11½ per cent of manganese showed that about 80 per cent of the original manganese was left in the deposited metal, giving it the properties of steel of this high manganese content.

Material to be Welded

In carrying out welding jobs it is very often forgotten that the composition of the metal to be welded has a most material effect upon the efficiency of the resulting weld. Welders are often blamed for bad results when the defect in the weld has been entirely due to the bad quality of the metal of which the job is composed. Cases of this description are occasionally found in connection with high phosphorus mild steel and particularly high phosphorus wrought iron, and in a piece of work recently met with the wrought iron attempted to be welded gave a structure as shown on the micro-photograph, Fig. 61. On this, large areas (white) showing the phosphoric structure can be seen. As the melting point of the phosphorous portion is low, it is immediately run into the joint with disastrous results. With this class of material a suitable flux should certainly be used.

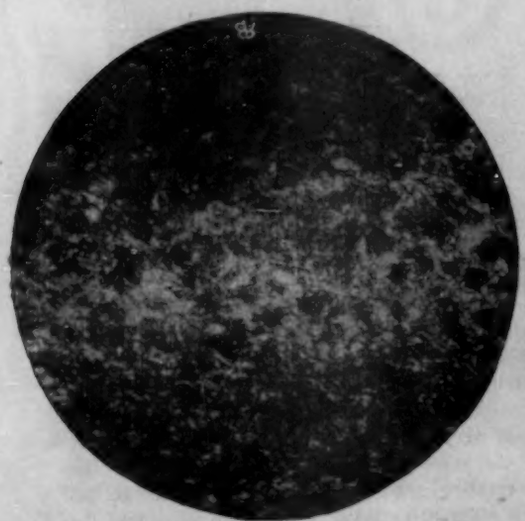

Fig. 54. Contact Weld of .20 Carbon Steel Rod.

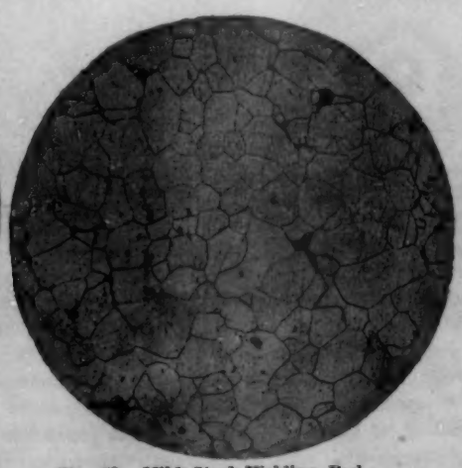

Fig. 57. Mild Steel Welding Rod.

Fig. 58. Sulphur in Feed Wire.

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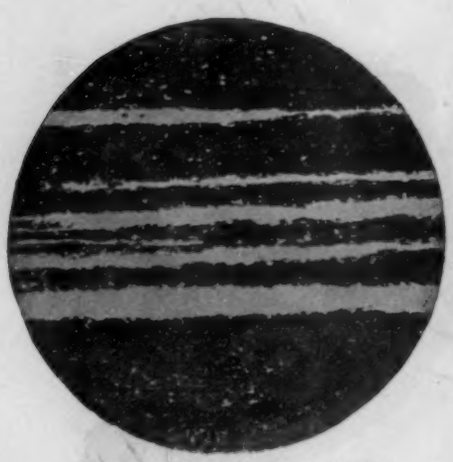

Fig. 59. Phosphorus in Feed Wire.

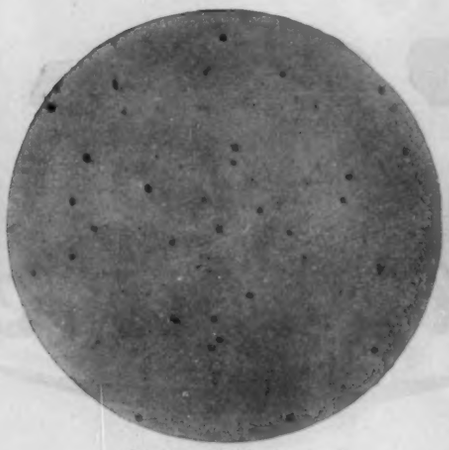

Fig. 60. Oxide in Feed.

Fig. 61. High Phosphorus Iron.

Non-Ferrous Welds

As showing that perfect welds can be made with the oxy-acetylene process in non-ferrous metals, the following micro-photographs have been prepared.

Fig. 62. Acetylene Weld in Copper.

The welding of copper is illustrated by Fig. 62 which shows perfect union at the junction. The welding of brass is shown by Fig. 63, in which it is extremely difficult to pick out any junction line at all. Aluminium can, of course, be perfectly welded by a welder who is blessed with sufficient intelligence and experience. The structure of this type of weld is shown in Fig. 64, and like all good aluminum welds, shows complete fusion at the junction. Aluminium alloy with a suitable filling material is, perhaps, more easily weldable than the pure metal, and to show how this alloy can be properly welded, the micro-photograph, Fig. 65, has been prepared. Examination of the structure will show that there is no distinct line of separation between the filling and the plate.

Cyc-Arc Welding

This perhaps, the most recent of all methods of welding, is a combination of arc and butt-resistance welding and gives extremely good results in certain classes of work. A micro-photograph showing the joining of a brass stud on to a mild steel plate is illustrated by Fig. 66. On this it will be noticed that there is an intermediate band which, no doubt, is an alloy of copper and iron, and probably a trace of zinc. This band is shown to greater advantage in Fig. 67, the micro-photograph being that of the same welded joint after annealing. It hardly need be said that on account of the high temperature of the arc nearly the whole of the zinc is volatilised from the brass at the junction of the metals.

The joining of dissimilar metals is no new thing in welding, as there are a small number of expert acetylene welders who make extremely good jobs in the uniting of all kinds of metals and alloys, both to themselves and to each other.

In conclusion, from what has been said above, it will readily be agreed that there is more in the art and practice of the welding of metals than appears on the surface, and for the various processes to advance in usefulness as they ought to do, it is necessary for a good deal of research work to be done. In addition, it is essential that the proper training of welders should be carried on along the best lines of instruction, and that certificates of competency should only be granted to operators after the fullest test of their capabilities.

Fig. 63. Acetylene Weld in Brass.

Fig. 64. Acetylene Weld in Aluminum.

Fig. 65. Acetylene Weld in Aluminum Light Alloy.

Why Some Welds Fail

OME Welds fail, due to a poor quality Welding Metal, some to a poor quality Plate or Base Metal, and others to the combination of both.

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WELDING RODS and ELECTRODES

GIVE WELDING A CHANCE

Editor:

During the several months of my membership in the American Welding Society, I have attended two meetings in the Metropolitan District. In making a survey of the discussions held at these meetings and in compiling the various papers as they have appeared in *The Welding Engineer*, it is to be assumed that the main objective—militarily speaking—if the followers of the torch and arc is to promote the art of welding. Much of the credit for this goes to the manufacturer of welding apparatus. He in particular, leaves no stone unturned to induce those who have not adopted welding to do so. Excellent propaganda has been distributed to these firms in which they are told of the vast sums that may be saved by the application of welding in their systems of production. Eventually they are sold a machine. Every one is happy. The manufacturer goes his way some dollars richer and happily believing he has helped to further the art. But it seems that all he has accomplished has been the selling of a machine. Now we have a firm with a new machine and a lot of literature. They form the nucleus of a welding department. A head for this department is created and furnished with the literature. They hire a welder or perhaps a demonstrator accompanied the machine and spent a few days breaking in a man to operate it. It is then that welding takes the stand on trial for its very existence and in many cases is left without counsel.

Fig. 66. Cyc-Arc Weld of Brass on Iron, as Welded.

Fig. 67. Cyc-Arc Weld of Brass on Iron—Annealed.

In the few years that I have been connected with welding, I have found only one welding foreman or supervisor who knew anything concerning welding. In every other instance the men in whose hands the destiny of welding was placed were unfit for the position. Some there were who honestly doubted the worth of it. Others foreseeing and fearing the result of an increase in the usages to which welding might be put, have thrown every obstacle in the path of it in an endeavor to bring discredit and ruin to the idea of welding.

It is all very well and necessary to strive to promote welding in new and untried fields, but our work should not stop with the selling of a machine. Why not consolidate what ground we have gained and stand by to offer a helping hand and to see as the saying goes, that they "do right by our Nell."

Among those who are injuring the future of welding is the man who sells apparatus and tries to minimize the human element. There are those who try to create the impression that all that is necessary to produce a perfect weld, is to point the torch or electrode in the general direction of the job and presto—it is done! I have been told that two years ago one firm advertised that a child could run their machine. This is not only unfair to the welder, but to the entire business.

Mr. Lorn Cambell, Jr., has written: "More will depend upon the 'human element' than anything else, for the welding plant will not do the welding any more than a blacksmith's forge will produce chains, chisels, tongs or any other item by itself; it is the 'know how' of the operator that really produces results. Any of us might go out and purchase a doctor's equipment, but this act would not make us doctors. Much schooling and experience is necessary, and so it is with the welder, whom we might term a metal doctor."

Mr. S. W. Miller, president of the American Welding Society, recently said: "The problems confronting our industry are many and varied. It is gradually being found out that welders cannot be made in six weeks except for the simplest operations. While there is not complete agreement as yet on the best method of training welders, the work is being gradually crystallized and the condition will improve rapidly as soon as those vitally interested appreciate the real need of proper and thorough training, not only in the actual handling of the apparatus, but in the fundamental principles involved."

Facts such as these, when stated by such noted authorities on the subject of welding should not be overlooked by the salesman when interviewing a prospective customer. It will be by far the best policy to acquaint the new buyer with the part that is played by the welder. Play fair with both because eventually he will discover this fact for himself and feeling that he has been stung and that this welding, like a number of other new-fangled ideas, is a failure, he may scrap his machine and warn every friend he has against it.

We are endeavoring to teach an idea which is almost if not entirely new to those whom we hope to interest. Once this interest has been awakened, let us strive to keep it alive. Many of us know and have felt the influences that are working against welding. There is no longer any doubt but that welding shall revolutionize many systems of production. The rivet will take its place beside other antiques. In boiler repairs, the patch—soft and otherwise—is fast going into the discard, and so we could continue through the different lines of business. But let us not lose sight of the fact that the man who drove the rivet and the man who put on the patch are not standing by applauding while the man behind the mask and goggles takes his place in the never-ending game of the survival of the fittest.

Let us demand and see to it, that there is given into welding the fair chance it deserves.

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ARC WELDING MONEL METAL*

The Use of Metallic Deoxidizers Has Resulted in Sound, Strong, and Moderately Ductile Welds

By P. D. Merica† and J. G. Schoener†

THE welding of Monel metal by the oxy-acetylene torch has never presented any particular or unusual difficulties, such, for example, as would not be presented by steel under the same circumstances. Rods, sheet and castings of Monel metal are regularly welded by this method and sound, strong and moderately ductile welds obtained. Although the practice in such welding is not essentially different from that used with steel, detailed instructions are issued by the International Nickel Company, producers of this alloy, for the oxy-acetylene welding of Monel metal in all forms.

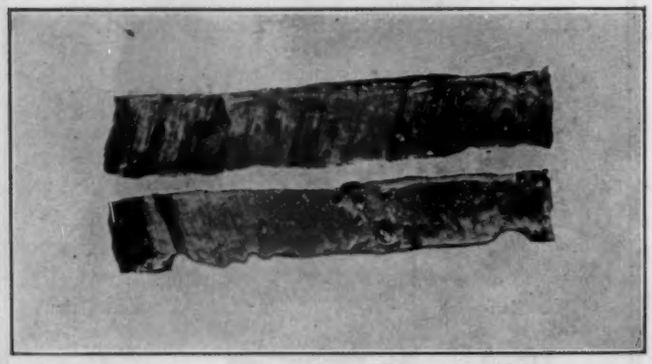

Fig. 1. Section Through Monel Metal Arc Weld Made Without Coating Electrode.

Attempts to arc-weld this metal have hitherto not proven similarly successful, whether by the carbon or the metallic arc method. In such trials the general experience has been that it is difficult to produce consistently, welds which are sound and free from blow-holes, ductile and free from shrinkage cracks.

Inasmuch as the arc-welding method offers in many cases the advantage over the oxy-acetylene one of lower cost, the research department of the International Nickel Company has for the past six or eight months been engaged in an effort to develop satisfactory arc-welding practice for the metal. The particular objective sought was to develop a method of producing sound and ductile welds, free from cracks.

The Welding Properties of Monel Metal

It is now generally recognized among those expert in welding that the behavior of a metal in the foundry; i. e., in being melted, poured and cast in a chill or sand mold throws light on its behavior during welding as, of course, would be expected. A weld is but a chill casting frozen to its mold. This viewpoint has proved particularly useful in the case of Monel metal.

When this metal (in its virgin form free from manganese) is melted and brought to the correct "pitch"; i. e., such that it has the right carbon content, which varies according to the use from 0.10 to 0.30 per cent, a casting poured from it either in a chill or in a sand mold will in general neither be malleable, ductile nor free from blow-holes. The addition of ferro-manganese or metallic manganese together with about 0.1 per cent of metallic magnesium will, however, "deoxidize" the molten metal and a casting or chill bar or ingot poured subsequently will be both sound and ductile.

It seemed apparent from consideration of the first difficulties encountered in arc-welding that the metal melted by the arc absorbed sufficient oxygen from the surrounding air that it required re-deoxidation in order to make it again malleable and sound. It may be observed that special deoxidation is not necessary in oxy-acetylene welding because the operator uses a reducing flame which protects the hot and molten metal from the air.

This view has been confirmed by subsequent tests and we have definitely ascertained that just as Monel metal must be "deoxidized" before casting into sand molds and ingots so must it be also "deoxidized" in producing satisfactory arc-welds. And the agents which are found to be superior for this purpose are the same as those used in the foundry; viz., magnesium, manganese and silicon, in the order of their importance for this operation.

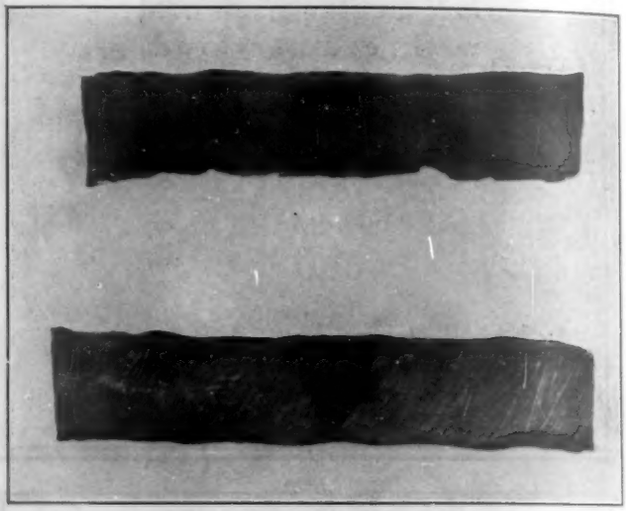

Fig. 2. Section Through Weld Made With Coated Monel Metal Electrode.

Deoxidation During Welding

We have found that these agents are best employed in the form of alloys, ground to from 50 to 100 mesh and applied to the welding rod of bare Monel wire as a thin coating. It is obvious that the alloys used for this purpose must be sufficiently brittle and preferably, also, soft, that they can be powdered. The binder which we have found entirely successful is very simply made of denatured alcohol containing ½ lb. to the gallon of shellac. Other similar binders would undoubtedly serve equally well.

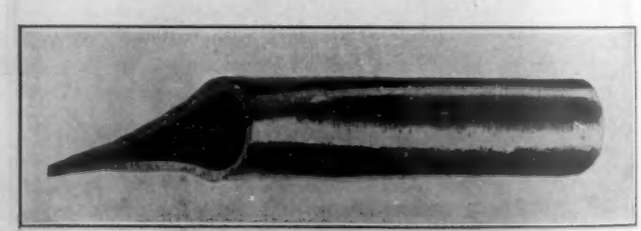

Fig. 3. Arc Welded Monel Sheet Which Was Purposely Bent Until It Cracked.

According to our experience the exact composition of this coating powder may vary within moderately wide limits, the essential thing being to introduce into the welded metal about the amounts of manganese and silicon and particularly of magnesium which are generally used for deoxidation in the foundry. Thus we should introduce from 0.05 to 0.50 per cent of magnesium, from

---

*From a paper presented before the Metropolitan Section of the American Welding Society.

†International Nickle Co.

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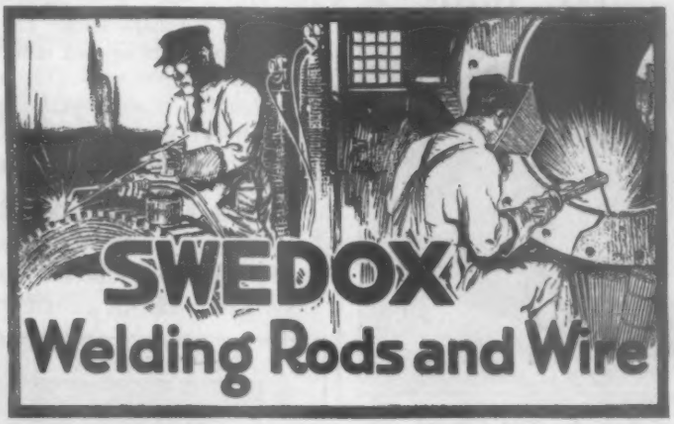

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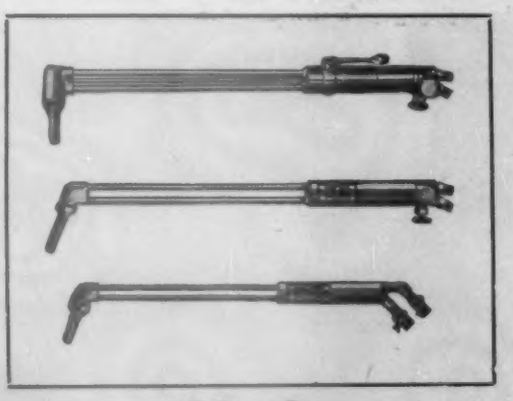

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0.20 to 1.00 per cent silicon and at least 0.20 per cent of manganese; the upper limit of manganese is not important, as an excess is not harmful. An excess of magnesium or silicon, however, will tend to produce dirty or brittle metal respectively.

Preparation and Composition of Coating Powder

We have applied these coatings dry simply by making a suspension of the powder in the dilute shellac solution and dipping the wire into it and allowing it to dry. The coating can also be

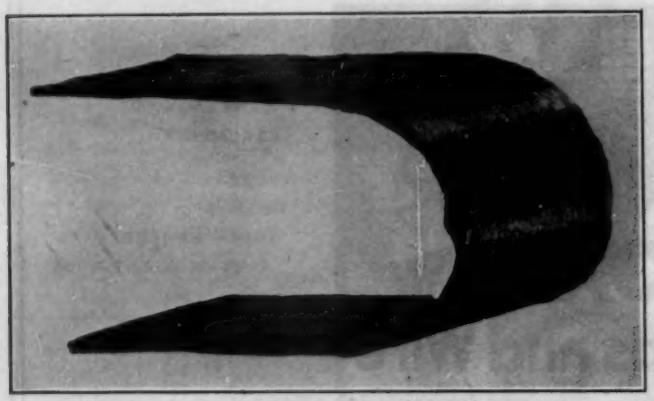

Fig 4. Bend in ¼ Inch Monel Metnl Arc Welded Plate.

applied by brush, although at greater expense of time and with greater loss of material. This coating we have found adheres well and will not be removed by packing and transportation. It will vary in thickness, but on a 5/32 inch wire will run about a pound to 600 feet and approximately 2 per cent by weight of the wire.

The alloys to be used in the preparation of the powder may vary widely when consistent only with the condition that all must be powdered and that certain limits noted above as to magnesium and silicon content always be maintained. We have had

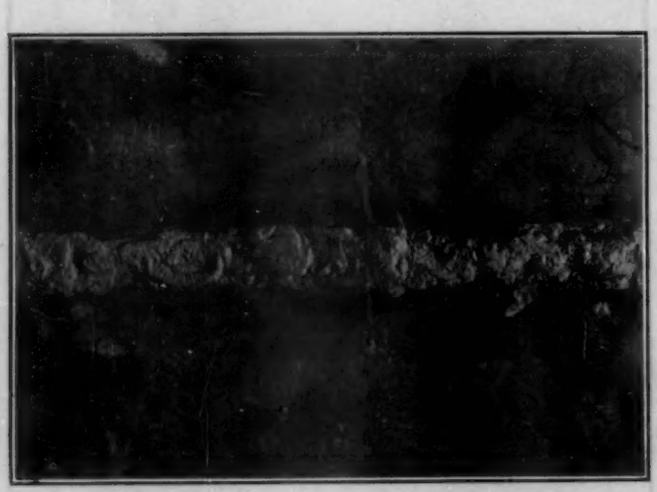

Fig. 5. Photograph of Monel Metal Arc Weld.

entire success using ferro-manganese or metallic manganese and one of the silicon-manganese-magnesium alloys produced by the Electro Metallurgical Company and having the following composition as described in their recent booklet:

	Grade No. 1 Per Cent	Grade No. 2 Per Cent	Grade No. 3 Per Cent
Magnesium	25 to 30	14 to 16	8 to 10
Manganese	20 to 25	27 to 33	45 to 50
Silicon	35 to 40	45 to 50	40 to 45
Carbon	Max. 0.20	Max. 0.20	Max. 0.20

Any of these alloys can be used alone or in conjunction with from 1 to 2 parts of ferro-manganese. Of course other alloys or combinations can be used to give similar results. We have used the manganese-magnesium-silicon alloys No. 1 and No. 2 alone and in conjunction with equal parts of ferro-manganese and have not been able to observe much difference between the results with the different composition.

Ferro-manganese alone of with ¼ of that part of ferro-silicon gives good welds at times, but they are not as consistently sound and ductile as with the simultaneous use of some magnesium. The latter seems to be the essential part of the coating, and although the manganese and silicon aid in deoxidation and in producing proper fluidity of the molten metal,—and consequently a good weld surface,—they serve perhaps also in large part as a diluting carrier for the magnesium. The latter cannot be ground and is also too reactive to be used in the pure form as it oxidizes before it ever gets into the weld. The manganese and silicon act to protect it until it is absorbed in the molten weld. A nickel-magnesium, nickel-copper-magnesium or nickel-silicon-magnesium alloy of similar type could be used as well for magnesium carriers, as they are also brittle.

Some Tests of Arc-Welds

To illustrate the results we have obtained with the use of the type-deoxidizer described above, the photographs shown in Figs. 1 to 6 are presented. Particular attention is drawn to photograph

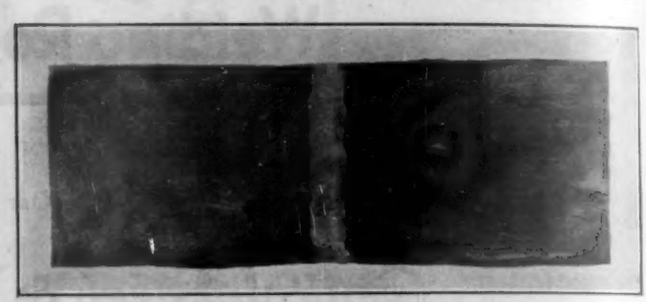

Fig. 6. Top Surface of Monel Metal Arc Weld, Ground, Buffed and Etched.

No. 1, which shows the blow-holes generally encountered when welding even with the greatest care, but using bare or other wire without the deoxidizer coating. This should be compared with No. 2 in which a section is shown welded with the deoxidizer coating.

These welds are sound and practically as ductile as are welds on ordinary low-carbon steel. The photographs show cold bends of from 30 to 45 degrees in ¼ inch Monel plate.

Tensile tests carried out on 2 inch and 3 inch wide arc-welded strips of Monel plate gave the following results, with which weld tests on the same material with the oxy-acetylene torch are given for comparison.

Tensile Tests of Arc-Welded and Oxy-Acetylene Welded 3-Inch Wide Strip of Monel Plate

Size	Tensile Strength, pounds per square inch	Elongation in 2 in.	Fracture
Arc-welds, in.			
.250x3	23,300	.....	Ragged—two blowholes
.255x3	39,200	.....	Ragged—no blowholes
.260x3	44,400	.....	Ragged—one blowhole
.245x3	47,800	.....	Ragged—four blowholes
.250x2	37,400	8.0	Irregular, slightly oxidized
.250x2	50,200	10.5	Ragged
.250x2	44,200	5.5	Ragged
.250x2	55,500	11.0	Irregular shear
.250x2	65,000	12.5	Ragged shear
.250x2	60,500	9.5	Ragged
.250x2	48,800	8.0	Ragged
.250x2	49,200	12.0	Sq. break
Average	47,100	9.70	
Oxy-acetylene welds, in.			
.250x3	44,600	10.5	Sq. tensile—two blowholes
.240x3	35,100	.....	Sq. tensile ragged—3 blow holes
.235x3	45,500	8.0	Sq. tensile—one blowhole
.230x3	50,500	9.5	Sq. tensile—3 blowholes
Average	43,900	9.3	

Special Features of Arc-Welding Monel

Aside from the use of the special deoxidizer described above, arc-welding with Monel metal is not essentially different in detail from that with steel.

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Positive safety, whereby any attempted flame propagation into the welding or cutting torch is expelled.

Consider also that TORCHWELD welding torches are machined from solid bar brass stock, and that principal parts of the cutting torches are similarly made; all permanent joints are brazed. Heavy duty welding tips are machined from solid bar copper stock, and are sufficiently heavy to make them sturdy, long wearing, and free from seating troubles. TORCHWELD torches are as well balanced as the beam on a scale; they do not tire the operator.

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of Monel, for work from ⅛ to ¼ inch, one of from 3/32 to ⅛ inch should be used, the best current being 180-200 and 75-125 amperes respectively.

It is best to make the whole weld at one operation and not to build it up in successive layers, as the latter method will likely give cracks and unsoundness. The weld should be well built up above the surface, as there are almost invariably small pinholes just under the surface of the weld, even with best welding practice.

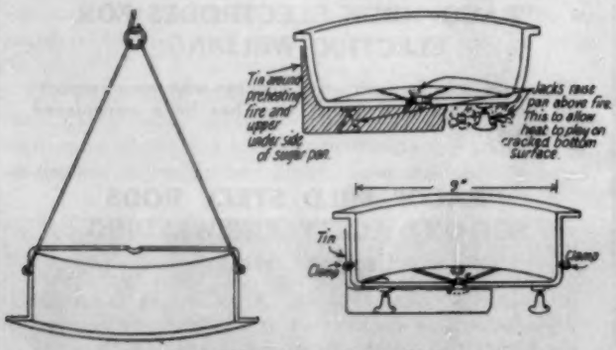
An important variation from usual practice with steel is that of making the welding rod positive instead of the work. When the latter is made positive the metal tends to drop from the electrode and does not flow freely and continuously.

In welding sheet, the usual angle should be left for shrinkage amounting to approximately ⅛ inch per linear foot of weld.

The plate, rod or casting should be well cleaned of all scale by grinding or machining on both sides of the weld edge and it is well to coat these edges, by the use of a brush, with the same deoxidizer as is used on the rod.

THESE WELDING OPERATIONS HAVE MADE FOR ECONOMY IN THE SHOP OF THIS WELDER

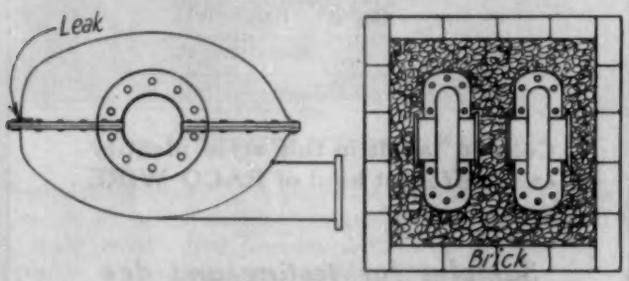
Chipping the V with a flogging chisel or an air-driven chipping hammer keeps the crack moving instead of repairing it, in many cases. Especially in this true in castings where there is little ductility in the metal. Harry Kohler, welder for the Kutztown Ford &


Tin around preheating fire and upper under side of sugar pan.
Jacks raise pan above fire. This to allow heat to play on cracked bottom surface.
9"
Tin
Clamp
Clamp

Preheating Large Sugar Pan.

Machinery Co., of Kutztown, Pa., has found that in chipping the V, excessive chipping may be overcome by drilling a small round hole just beyond the end of crack. Any break will terminate in this round hole.

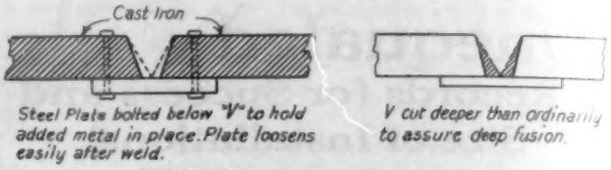
In welding several cracks in the bottom of a large sugar pan



How Pump Castings Are Preheated.

Mr. Kohler used some ingenious preheating methods. Instead of building a fire all over the pan, as is the usual practice, he changed the scheme a little. By raising the pan up on jacks, he found that he could build his fire under the pan in such a way as to have the flames play directly on the broken parts and also upon a generous area around them. This was affected by placing pieces of sheet tin about the pan after the fire had been built under it, thus obviating the necessity of heating the upper parts of the pan where it was not required. The economy brought about by this move can be realized when the size of the pan is taken into consideration. It was 9 feet in diameter, about 3 feet deep and about 2½ inches thick. An overhead traveling crane was available. This was also a very helpful facility, for it assisted greatly in shifting the heavy pan about.

Two pump casing castings were brought to Mr. Kohler, which had cracks in them to foundry shrinkage. These castings were difficult to weld in, inasmuch as they were all round with the exception of a flat flange. He preheated both castings at the same time and cut the V's with a cutting torch. After the chamferes were fully prepared plain raw iron rod was added until the pieces were welded. Asbestos sheets were used to cover the job during the heating process.


Cast Iron
Steel Plate bolted below "V" to hold added metal in place. Plate loosens easily after weld.
V cut deeper than ordinarily to assure deep fusion.

Suggestion for Getting Penetration on Heavy Castings.

As an aid to the welding of heavy section where there is a possibility of not achieving sufficient penetration, Mr. Kohler suggests the use of a steel plate bolted under the V. Then the side walls of the V should be chipped so that some of the plate will show beneath. This, he states, makes it certain that all sides of the metal have been caught. The plate comes off easily when the casting cools.

BASTIAN-BLESSING CO. "ADOPTS" TORIT LINE

An arrangement has been consummated between The Bastian-Blessing Company, manufacturers of Rego welding and cutting apparatus, and the St. Paul Welding and Manufacturing Company, manufacturers of the Torit welding and cutting equipment, by which The Bastian-Blessing Company has taken over the entire output of the St. Paul Welding and Manufacturing Company's line of soldering equipment, trucks, preheaters and acetylene generators.

The St. Paul Welding and Manufacturing Company on the other hand, will be the service distributors of Rego welding and cutting equipment throughout the Northwest. They will carry a complete stock of welding and cutting equipment and supplies and operate an up-to-date repair service station at St. Paul, Minnesota.

Wilson Welder & Metals Company, Inc., 132 King Street, New York, N. Y., recently appointed King-Knight Company, Underwood Building, San Francisco, California, exclusive representatives in Central and Northern California for Wilson Plastic-Arc Welding Machines and Wilson "Color-Tipt" Metals.

The Standard Welding Co., 665 South Water Street, Providence, R. I., is contemplating a new plant or addition within the near future to take care of increased business. Harry T. Prince is president of the company.

The Goldsmith Welding & Engine Co., Canton, Ohio, has recently been organized and it is reported that it will establish a plant at Harrisburgh Road and Sixteenth Street, N. E., for the manufacture of welded steel storage tanks, racks and frames. A jobbing department and repair works will be conducted. V. J. Goldsmith is president and general manager.

Classified Ads

Help Wanted—75c per line, minimum 4 lines.
Jobs Wanted—4 lines free.
Other Ads—$1.00 per line, minimum 4 lines.
Counted 8 words to line. Add 6 words for keyed address.

Acetylene Cylinders Bought and Sold—I can save you money on the purchase of Prest-O-Lites and other acetylene cylinders, or will help you if you have any to dispose of. Robt. B. Dyar, 140 So. Dearborn St., Chicago, Ill.

Wanted to Purchase—Service Agreements on Prest-O-Lite welding cylinders. Advise number of cylinders and best price. Address 37, care The Welding Engineer.

Wanted—By Oxygen Company in Southern City, salesman to handle equipment, gases and supplies, one who can demonstrate. Answer, giving amount salary or commission expected. Address 38, care The Welding Engineer.

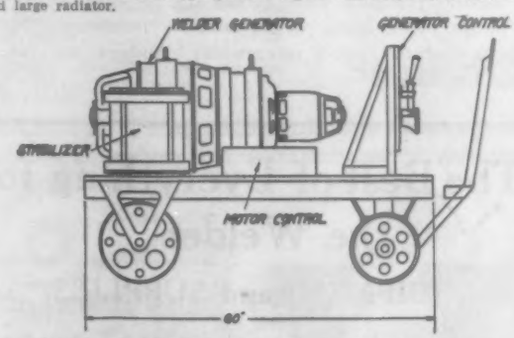
Position Wanted—Acetylene welder, 9 years' experience on all metals. 2 years in U. S. Navy as acetylene welder and blacksmith. 35 years old and married. Will go most anywhere. Address 39, care The Welding Engineer.

For Sale—Two-thirds interest in a welding corporation in a western city four hundred thousand population. Price twelve thousand dollars. Valuable property lease, stock and equipment will inventory proportionately very much more. Owner wishes to retire on account of age. Average daily business thirty to one hundred dollars. Splendid opportunity for active, experienced man. Address 40, care The Welding Engineer.

Wanted—The Chicago office of the Carbic Manufacturing Co. has openings for two experienced oxy-acetylene salesmen. Address or call at 565 W. Washington Blvd., Chicago.

FOR SALE!

1 Electric Welding Co. of America GASOLINE Driven Portable Outfit, self contained in steel frame, capacity 160 amp., max. voltage 60 v., 700 rpm., 4 cyl. vertical automobile type gasoline engine with magneto, carburetor, fan and large radiator.



2 used Portable Lincoln Electric Welding Outfits like cut shown above, continuous capacity, 150 amp. DC., intermittent capacity 200 amp. D.C.; volts 1 to 40. Driving motor is part of outfit and suitable for an electric power supply of 3 phase 60 cycle current at either 110, 220 or 440 volts. In practically 100% new operating condition, all bearings new ball bearings. This is an opportunity to get the equal of a new outfit at half price.

1 used Portable Outfit like the above except that the driving motor is suitable for an electric power supply of direct current 220 volts. This Outfit was operating properly when taken out of service on closing of the plant.

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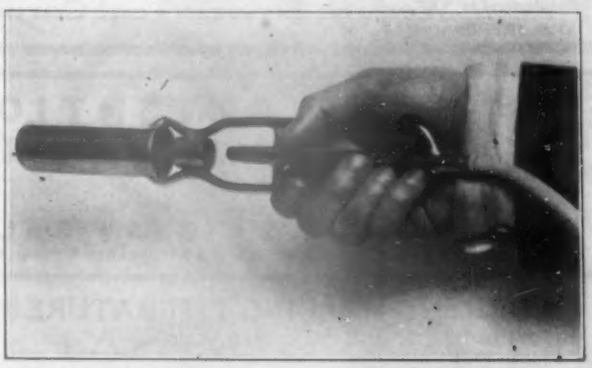

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CURRENT WELDING LITERATURE

ARC WELDING IN ELECTRIC RAILWAY SHOPS—publication just issued by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The publication, which is known as Leaflet No. 1824, describes the advantages of arc welding and gives figures showing the great saving possible by reclaiming worn out parts. Worn and broken brake shoes, side bearings, truck frames, bolsters, door castings, gear cases, air reservoirs, etc., can be reclaimed at a great saving. The electric welding process is easy and rapid, and many repairs can be made without dismantling the defective parts, which greatly lessens the time that cars are kept out of service. Increasing technical knowledge regarding arc welding has extended the scope of the process to many new operations, and improvements in welding equipment, many of which are described in this publication, have greatly increased welding afficiency

PROPERTIES OF ARC DEPOSITED METAL, by O. H. Escholz—Technical discussion of some of the more important characteristics of arc deposits, using direct current arc, bare open-hearth steel electrodes (0.15 per cent carbon and 0.5 per cent manganese content) and a skilled operator. Tabulated data on properties of metal in static stress, compression, shear, etc. Forging arc fused steel. The results of the investigation, concludes the author, justify a more optimistic attitude toward the performance and use of cast arc metalin structures subjected to stress variations of a low order of magnitude or of a slow period, as in tank cars and fired and non-fired pressure vessels.—Iron Age, June 29.

WELDING DURALUMIN, by H. C. Kuerr—Methods employed in experimental work in the Naval Aircraft Factory, and the results obtained. Difficult and complicated joints should be avoided in design, and expansion strains must be taken care of. Provision should be made for heat treating of entire part after welding and protecting it from exposure to moisture.—Automotive Industries, May 4.

THEORY AND PRACTICE OF REGULATORS, by G. Tabarly—Reasons why a regulator is absolutely indespensable, and dangers in operating without them. Necessary features of a good regulator. Classification of regulators and illustrated descriptions of standard types marketed in France.—Revue de la Sondure Autogene, Paris, May, 1922.

AUTOMOTIVE SERVICE METHODS AND EQUIPMENT, by Howard Campbell—Description of service welding and machining operations in the plant of Yellow Cab Co., Chicago. Valve seats are replaced by placing a quarter-inch disc of carbon under valve opening and building valve port full with new metal, boring and seating in the usual manner. Charcoal ovens are used for preheating. Scored cylinders are repaired by adding new metal. When welding crankcases, distortion is overcome by bolting a heavy shaft to the bearings and a one-inch plate to the flange. Crankcases are preheated in the vicinity of the break.—American Machinist, July 6.

SOME PRINCIPLES OF THE CONSTRUCTION OF UNFIRED PRESSURE VESSELS, by S. W. Miller— Composition of best base material and welding wire for good welds. Weakness of the Single-V weld. Superiority of welded tanks. Results of tests. Two appendices deal respectively with the testing of welded specimens and the testing of all-welded tanks.—Acetylene Journal, July.

WELDING LAMINATED SPRINGS, by D. Richardson—Spring plates should be welded only as an emergency repair. A high carbon steel welding rod should be used and the plate welded from one side only, with a slight re-inforcement. Joint should be hammered at a cherry red, annealed at a yellow heat, cooled and then re-annealed at medium cherry red. Pack both sides of plate with wet asbestos to prevent heat conduction.—Acetylene and Welding Journal, London, June, 1922.

AUTOMOBILES REPAIRED BY WELDING, by George Green—Experienced workmen who study the business make satisfactory repairs on frames, housings, waterjackets, crankcases, fenders and other parts. Some general hints on these jobs are given.—Canadian Welding Journal, Toronto, June, 1922.

ARC WELDING IN MACHINERY CONSTRUCTION, by A. M. Candy—Large variety of defective or accidentally damaged shop machinery is effectively repaired by arc welding. Examples of a large flywheel, a large lathe bed, shafts machined undersize, etc. Coasting vessel was built all arc welded without rivets. Small mill building (40x60 feet) was erected by welding process. Ammonia tanks can be successfully arc welded. Discription of modern arc-welding generator set.—Engineering World, April, 1922.

AEROIL OIL BURNING APPLIANCES—Bulletin No. 20 of Aeroil Burner Company, Union Hill, N. J. Eight pages of information about the Aeroil line of kerosene burners and torches.

ELECTRICAL AND MAGNETIC WELD TESTING AS APPLIED TO BUTT WELDED STEEL PLATES, by T. Spooner and I. F. Kinnard—Reprint issued by American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Describes a series of laboratory tests applied to arc butt-welded steel plates to determine the possibility of developing electrical and magnetic tests that will be capable of revealing the quality of such welds. Electrical, magnetic and tensile tests showed a very fair general agreement among themselves and with the known quality of the welds as reported by the welder. Possibility of altering apparatus so as to make these tests commercially useful.

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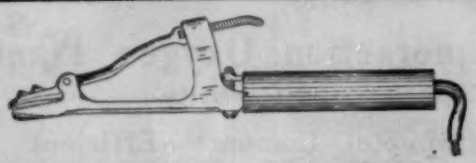

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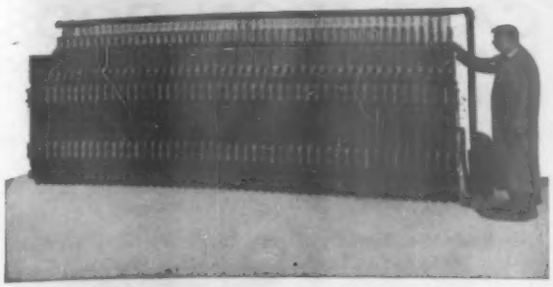

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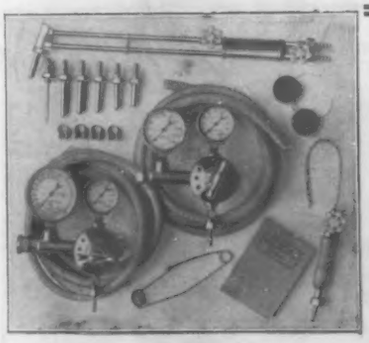

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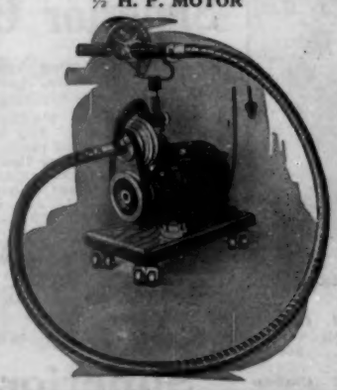

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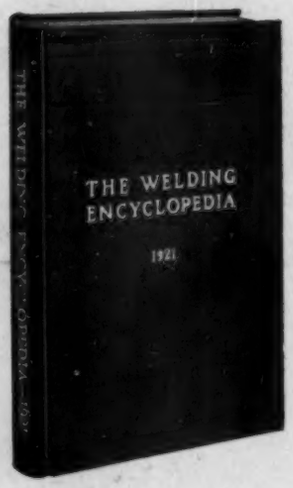

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